Education for a Changing World:

A Mixed-Methods Study of Cognitive Flexibility in Rwandan Primary Schools

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This dissertation is submitted for the degree of Doctor of Philosophy.

PREFACE

This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text.

It is not substantially the same as any that I have submitted, or is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text.

I further state that no substantial part of my thesis has already been submitted, or is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. It does not exceed the prescribed word limit for the relevant Degree Committee.

ABSTRACT

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Stephen H. Bayley

In 2016, Rwanda followed the example of numerous African countries and introduced a competence-based curriculum for all levels of its education system (Mushimijimana, 2016; Ngendahayo & Askell-Williams, 2016). Such curriculum explicitly promotes skills for adaptability like creativity, innovation and problem solving, so as to prepare the Rwandan population for an uncertain future and a changing world (Rwanda Education Board & MINEDUC, 2015). However, little is currently known about how these competencies improve, and especially in low-resource educational settings. This thesis therefore aims to address this gap by examining the measurement and development of Rwandan pupils' skills for adaptability, their relationship with other learning outcomes and the current practices that may aid their growth in public primary schools.

To achieve this, the research adopted a psychological lens to focus on the development of Rwandan children's cognitive flexibility, which Diamond (2014) describes as "creatively 'thinking outside the box', seeing anything from different perspectives, and quickly and flexibly adapting to changed circumstances" (p. 206). The empirical study also drew on theories concerning both educational quality and child development to frame the inquiry, specifically the Implementing Education Quality in Low-Income Countries (EdQual) model (Tikly, 2011) and Bronfenbrenner's bioecological systems theory (Bronfenbrenner, 1979, 1986).

The mixed-methods research design included fieldwork conducted over 4-5 months during 2018 in four public primary schools serving low-income households in Kigali, the capital of Rwanda. The quantitative component of the study comprised capturing data from a cross-section of 306 pupils randomly selected from age-in-grade learners in both Primary 1 and 4 classes. Each child was assessed one-to-one in their mother tongue by a trained Rwandan enumerator using adapted versions of two established psychological tests to measure their cognitive flexibility. Pupils were also assessed for their broader psychological development (executive function), non-verbal reasoning and basic literacy skills. In addition, they were briefly surveyed with age-appropriate tools to ascertain information concerning their home situation and prior schooling experiences.

Following conclusion of the pupil assessments, semi-structured interviews and observations were undertaken with head and classroom teachers to address the qualitative aspect of the research. In particular, the interviews aimed to explore teachers' perceptions and attitudes regarding pupils' cognitive competencies, while the lesson observations looked to identify existing practices that *could* enhance learners' cognitive flexibility.

Statistical analyses in Stata revealed that both measures of cognitive flexibility showed good reliability and a significant correlation with medium effect size. Learners in Primary 4 performed significantly better than those in Primary 1 but, given the cross-sectional nature of the research, the cause of this difference and whether it results from formal education or other factors remains unknown. Disaggregating the data by cohort, Primary 4 children from single-parent families scored significantly higher than those from two-parent households and there was some, albeit limited, evidence that could suggest higher cognitive flexibility among children from poorer households. Regarding wider learning outcomes, pupils' cognitive flexibility significantly predicted their non-verbal reasoning and executive function, and vice versa. Contrary to wider literature, however, there was limited evidence of any significant association between their cognitive flexibility and their reading skills.

Qualitative data from the interviews were analysed in NVivo and revealed that teachers perceived skills for adaptability as conferring a mix of individual and collective benefits, to build originality, self-reliance and independence in learners' everyday lives, and more responsible citizens who can contribute to Rwanda's national development. Within the classroom, teachers used group-based activities to encourage collaboration and a range of techniques, learning aids and materials, often sourced from their own homes, to impress on children the practical relevance of their education. Frequent switching between English and Kinyarwanda in lessons might also inadvertently nurture pupils' cognitive flexibility, albeit at a possible cost to their wider learning.

The findings of the study provide a valuable contribution to growing global research on children's psychological development in lower-income settings. Using mixed methods among different stakeholders in several schools also offered multiple perspectives for better understanding the processes through which learners acquire and build important cognitive competencies, not least their creativity, innovation and problem solving. By way of limitations, the use of cross-sectional rather than longitudinal data precluded any claims around causality and future research could examine any possible interactions with the pupils' numeracy skills.

In conclusion, this thesis draws on both quantitative and qualitative data to argue that child psychology provides an important basis to understand, research and foster learners' 21st century competencies, even in lower-income countries where evidence remains scant. Specifically, it proposes that cognitive flexibility, the capacity to think creatively, adapt quickly and adopt different perspectives, presents a valuable framework for nurturing essential skills that offer wide socio-economic benefits in settings like Rwanda. Implications from the study include increasing pre-primary schooling and expanding the resources, planning and training available to implement the new curriculum effectively and thereby support children's more diverse educational competencies. Similarly, the thesis identifies the need to maximise learner-teacher continuity and pedagogies like group-based exercises for pupils to leave school equipped with the skills to think 'outside the box', understand different points of view and adapt for life in the rapidly changing world.

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Utazi umukungu yima umwana

If you give a child opportunities, you never know what

they will achieve in the future.

Rwandan Proverb

(UNICEF & NURC (2004)
cited in Pells (2011))

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ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
BERA	British Educational Research Association
CI	Confidence Interval
DCCS	Dimension Change Card Sort
DMAST	District Master Subject Trainer
EdQual	Implementing Education Quality in Low-Income Countries
EGRA	Early Grade Reading Assessment
FARS	Oral Reading Fluency Assessment of Rwandan Schools
FIST	Flexible Item Selection Task
GDPR	European General Data Protection Regulation
IDELA	International Development and Early Learning Assessment
ICT	Information and Communications Technology
LMTF	Learning Metrics Task Force
MELQO	Measuring Early Learning Quality and Outcomes
MINEDUC	Republic of Rwanda Ministry of Education
MCST	Multidimensional Card Selection Task
NACCCE	National Advisory Committee on Creative and Cultural Education
NGO	Non-governmental Organisation
OPRA	Object-based Pattern Reasoning Assessment
REB	Rwanda Education Board
RQ	Research Question
SE	Standard Error
SES	Socio-economic Status
TEACh	Teaching Effectively All Children
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
VSO	Voluntary Services Overseas
WCST	Wisconsin Card Sorting Test

CHAPTER 1 – INTRODUCTION

Education systems worldwide face growing pressures to equip their learners with the right mix of aptitudes, knowledge and competencies. Governments now aspire to foster so-called '21st century' skills among their citizens to balance the various demands of increased economic productivity, poverty reduction and progress towards the Sustainable Development Goals (Nilsson et al., 2016; Trilling & Fadel, 2009). Workforces must no longer be just literate and numerate, but also innovative and adaptable to respond to the evolving needs of a knowledge economy age and a quickly changing world (Jeffrey & Craft, 2001; Kivunja, 2014a). Indeed, global threats posed by climate change, ageing populations and most recently the COVID-19 pandemic have highlighted the importance of higher-order competencies such as creativity and problem solving to address today's most pressing challenges (Hannon, n.d.).

Schools play a critical role in laying the necessary cognitive foundations for learners to gain these valuable skills for adaptability (Pellegrino & Hilton, 2012; United Nations Educational, Scientific and Cultural Organization (UNESCO), 2012). However, questions abound regarding the precise pedagogical processes that underpin their acquisition, especially among deprived children in resource-poor settings. Historically, there has been little research in lower-income countries on learners' cognitive flexibility and the other executive functions that provide the psychological bases for their creativity, innovation and problem solving (Pope et al., 2019; Schulson, 2020). Similarly, interactions between any relevant studies, educational policy and the school-based practices that may nurture such skills have been limited at best (Abadzi, 2016).

This research aimed to address those gaps through a mixed-methods investigation of children's cognitive flexibility development in Rwanda. In particular, the study posed the following specific questions: (1) How can Rwandan pupils' cognitive flexibility be measured during the course of their public primary education and what factors are associated with its development? (2) How does the cognitive flexibility development of Rwandan public primary school pupils relate to their other cognitive competencies? (3) What are the perceptions and attitudes of Rwandan public primary school teaching staff regarding the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility? and (4) What practices or behaviours are Rwandan public primary schools using to enable the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?

Seemingly the first study of children's executive functions in Rwanda, the research focused on pupils attending public primary schools in disadvantaged areas of the country's capital, Kigali. Learners' skills for adaptability in these and similar contexts have been of particular interest to me since I first worked in Rwanda in 2010. Spending considerable time in a local school, I witnessed high levels of rote memorisation and 'chalk and talk' pedagogies, which gave few opportunities for children to build competencies like creativity and problem solving. I returned in 2012 to conduct Masters research on the perceived value, relevance and development of such skills among international non-governmental organisations (NGOs), which provided a prelude for the current inquiry (Bayley, 2012, 2015).

This thesis therefore describes in detail my research undertaken to explore learners' cognitive flexibility development in Rwandan primary schools. The second chapter opens the study with a review of the existing literature regarding the burgeoning demand for skills for adaptability, an examination of cognitive flexibility as the focus of the research, and a discussion of the key characteristics of the Rwandan context. The third chapter then outlines the philosophical paradigms, theoretical frameworks and case study methodology that underpinned the research, as well as the ethical use of interviews, observations and pupil assessments to capture mixed data in the schools. The fourth and fifth chapters describe the quantitative analyses and findings, before the sixth and seventh chapters detail the results of the qualitative methods. Finally, the eighth chapter pulls the different components together to discuss the key findings, contributions and implications of the study to close the thesis.

CHAPTER 2 – LITERATURE REVIEW

2.1 Cognitive Skills for Adaptability

2.1.1 Global Demand for 'Cognitive Skills'

The concept of a 'skill' or 'competency' is notoriously difficult to define. Typical interpretations emphasise an ability to perform a prescribed function, however, precise interpretations appear to depend on the particular context, from education to neuroscience, from recruitment to economics (Abadzi, 2006; Brown et al., 2001). Defining *cognitive* skills and competencies[1] arguably presents an even more complex and contentious endeavour. Understandings have been evolving since an early formulation by Bloom, Engelhart, Furst, Hill and Krathwohl (1956) which categorised learners' capabilities by domain (cognitive, affective and psychomotor) and codified them into a hierarchical taxonomy, capped by the analysis, synthesis and evaluation of information.

Subsequent efforts have achieved some degree of convergence but a precise and universal definition remains elusive. On the one hand, cognitive competencies denote an individual's ability to think, solve problems and learn life skills (Adams, 2012; Learning Metrics Task Force (LMTF), 2013). Such competencies similarly imply the development of well-learned and –practised behaviours for learners to link items in their memory and apply them as knowledge valuable in a particular context (Abadzi, 2016; Pellegrino & Hilton, 2012). On the other hand, educational planners now use a plethora of different terms, for example, 'core', 'generic', 'transferable' and 'catalytic', to refer to learners' desired mental capacities (UNESCO, 2012; World Bank, 2011). This can give rise to a risk of 'jangle fallacy', using different expressions to describe the same conceptual construct, which can undermine the efficacy and impact of all related discussions (Coleman & Cureton, 1954).

Notwithstanding the challenges in defining skills generally and cognitive competencies more specifically, there is evidence of a growing international demand for learners to acquire skills above and beyond the traditional focus on literacy and numeracy. For instance, there has been increased interest in categorising and classifying various 21st century skills, deemed to include critical thinking, collaboration and communication, to identify what children should now learn

[1] The terms 'skill' and 'competency' are used interchangeably throughout this thesis.

to live and operate effectively in the modern digital world and a knowledge economy age (Kivunja, 2014a, 2014b; Partnership for 21st Century Learning, 2016; Trilling & Fadel, 2009).

From the suite of 21st century skills, many governments similarly recognise the potential importance of *higher-order* cognitive competencies for adaptability within their workforce. These include problem solving and creativity which in a review by Amadio (2013) of curricula in 88 countries were ranked third and fourth (behind communications and social competence) in terms of key cross-thematic emphases. Likewise, in a study with stakeholders in Kenya, Mexico, the Philippines and South Africa, respondents including parents, teachers and government personnel highlighted creativity, innovation and problem solving as valuable skills important for their children to develop for success in modern life (Care et al., 2017).

However, these competencies also defy easy definition, measurement and discussion. Many frameworks employ slightly different terms for the same or similar constructs, or ignore the relevance of culture or context in their conceptualisation (Coleman & Cureton, 1954; Kandemirci, 2018; Westwood & Low, 2003). Efforts to assess creativity, innovation and problem solving may similarly overlook the realities of participants' daily environments or underestimate the complexity of processes involved in their use. For example, traditional assessments of creativity that involve drawing may be unsuitable for children without regular access to pencils and paper, while problem solving requires individuals to have certain basic competencies to combine and reorganise existing knowledge to achieve the best solution (Mumford et al., 1994).

Nevertheless, recent efforts by the Harvard Taxonomy Project have sought to address the challenge of jangle fallacy among different social-emotional outcomes (Jones et al., 2019). Specifically, the EASEL Lab identified related themes and traits across 40 international skills frameworks, including commonalities between perceptions of creativity, innovation and problem solving. As distinct but related constructs, they enable learners to adapt themselves and their behaviours to new circumstances, and to apply knowledge and competencies in their everyday lives (Pellegrino & Hilton, 2012; Trilling & Fadel, 2009). Perceptions of 'creativity' entail individuals or groups acting imaginatively or thinking divergently to produce original and valuable outcomes, while 'innovation' is either used interchangeably with creativity or described as the product of such an endeavour (Guilford, 1957; Kandemirci, 2018; Westwood & Low, 2003; Zabelina et al., 2019). In a similar vein, 'problem solving' describes the process of working creatively or more routinely towards achieving a certain task or resolving a particular challenge (National Advisory Committee on Creative and Cultural Education (NACCCE), 1999).

2.1.2 The Prospective Benefits

Improved cognitive competencies like creativity, innovation and problem solving could confer various economic and social benefits, to individuals and their communities alike. Indeed, such possible advantages accord with wider theories and rationales for education investment which emphasise its role to build human capital and promote personal capabilities (Becker, 1993; Sen, 1999).

In terms of financial gains, Duening (2010) draws on early research into how successful entrepreneurs think to suggest that cognitive skills such as creativity and problem solving could support business people, from small market traders to commercial executives, to better identify emerging opportunities and how best to exploit them. Imagination to understand client or stakeholder needs may likewise help enterprises to plan effectively for more tailored customer solutions or sustainable livelihoods. At a larger scale, Craft, Jeffrey and Leibling (2001) propose that innovation could foster greater job creation and entrepreneurship, and enable workers to adapt to changing labour markets with heightened efficiency and competitiveness.

Through enhanced job opportunities and more robust livelihoods, improved problem solving and creativity could potentially work to alleviate the root causes of social challenges, including poverty, division and conflict. Indeed, Nenty, Adedoyin, Odili and Major (2007) suggest that cognitive skills can help learners make more direct contributions to societal development. At both micro and macro levels, creativity, innovation and problem solving may empower individuals, their families and their communities to participate more proactively, plan more effectively and map out the necessary steps to improve their lives (LMTF, 2013). Imagination could likewise support them to pre-empt and mitigate risks, such as financial shock or threats to food security (Duffy, 2006).

Further, creativity and imagination may foster stronger attitudes of tolerance, inclusion and social cohesion. Individuals could learn to imagine and identify with other perspectives, different religions or rival backgrounds (Greene, 1995; NACCCE, 1999). This may help to decrease the stigmatisation of alternative lifestyles, reduce tendencies towards violence and extremism, and prepare young “minds to live in and cope effectively with a world of various pluralisms” (Commonwealth Commission on Respect and Understanding, 2007, p. 63).

Finally, such skills for adaptability hold particular significance in today’s global climate. Both Ungar (2011, 2015) and Masten (2014, 2019) highlight their importance for resilience among people in stressful environments or adverse situations, whether these result from climate change, political instability or migration following protracted conflict. Similarly, the COVID-19 pandemic has forced populations around the world, in both higher- and lower-income contexts, to change the ways they live, work and interact, now and for the immediate future.

Creativity, innovation and problem-solving skills may thereby tackle a host of very real 21st century challenges. However, the weight of such claims and value of such benefits must be understood in light of certain key caveats and important assumptions. First, there is little, if any, rigorous, empirical or longitudinal evidence to substantiate the assertions, which rely largely on speculative and unproven theories of change. A review by Pellegrino and Hilton (2012) of studies into the impact of more generic 21st century competencies, comprising cognitive and non-cognitive skills such as conscientiousness and agreeableness, found data to be limited and uneven, showing modest correlational relationships and only *suggestive* of causal linkages at best. In reality, it may be difficult, unethical or perhaps impossible to isolate, monitor and measure the development of individual cognitive competencies independently from wider schooling effects, so as to demonstrate causality or quantify the relative benefits.

Second, the claims presume that competencies such as creativity, innovation and problem solving are individually constructed, acontextual and transferable to apply equally in different socio-political settings. Tikly et al. (2003) reject this notion of a universal form, emphasising the importance of context in developing and exercising skills and competencies. In a qualitative study exploring perspectives across both urban and rural Rwanda and Tanzania, they claim that cultural values and norms are “an important ingredient for developing social capital” (p. xi). They further discuss how different cultural aspects can encourage or block skill formation and, with specific reference to Rwanda, note how ‘traditional’ attitudes towards authority have historically discouraged individuals from taking their own initiative. Likewise, Kraak, Lauder, Brown and Ashton (2006) regard competencies as being collectively constructed and embedded within particular political, economic and cultural settings to combine as a specific set of capabilities.

Nevertheless, the mobility of international workers and the rise of global competition for jobs make a compelling case for the transferability of skills, once acquired. Notwithstanding the value of local knowledge, indigenous customs and relevant expertise, the ease of outsourcing labour to remote factories or skilled foreign migrants undermines the idea of competencies as strictly culturally bound. Regarding skill *development*, neuroscience research suggests that:

> Human brains process information in much the same way, and similarities may be more important than individual or cultural differences. Such unifying principles may point to common solutions for educating disadvantaged children efficiently and may be applicable from preschool to university (Abadzi, 2006, p. 8).

Third, and most importantly, the benefit of children learning to think creatively and solve problems presupposes their mastery of certain cognitive processes that underpin and enable such operations. Diamond (2014) highlights the need for core executive functions, such as working memory, inhibitory control and cognitive flexibility, before learners can engage more meaningfully with higher-level mental endeavours like problem solving, planning or reasoning. For instance, evidence suggests that individuals with weaker working memories tend to recall more irrelevant information when solving a problem (Cornoldi et al., 2015).

Further, Abadzi (2016) emphasises the risks associated with government policies and initiatives that fail to engage with neuroscientific research into the acquisition of skills and competencies. She suggests that such oversight reflects a failure to comprehend the full range of basic cognitive behaviours that learners must not just master but also automatise before they can tackle more complex functions successfully. She argues that, at present, highly educated planners operate on the basis of memory biases which optimistically overestimate the core competencies of the masses and underestimate the effects of poverty on the developing brain. Without better informed dialogue and increased reliance on research, governments and their advisers could not only compromise children's long-term educational prospects, they could exacerbate the skills gap at the expense of the most economically disadvantaged populations.

In light of these issues, the next section examines the nature, development and assessment of cognitive flexibility, as a core executive function and a key component of children's skills for adaptability.

2.2 Understanding Cognitive Flexibility

2.2.1 Cognitive Flexibility and Core Executive Functions

Cognitive flexibility comprises one aspect of certain mental or *executive* functions that develop during an individual's childhood and adolescence. In this case, 'executive' can be understood both in terms of the conscious decision being made and the execution of that choice (Zelazo et al., 1997). Executive functions thereby facilitate behaviour towards the attainment of a particular goal and enable learners to exert progressively more deliberate control over their thoughts and actions, as required by the specific context or new environment (Diamond, 2013; Dias et al., 2013; Garon et al., 2008; Jacob & Parkinson, 2015; Wiebe et al., 2014).

Executive functions are typically associated with processes in the brain's prefrontal cortex (Best et al., 2009; Garon et al., 2008). They help to regulate thoughts and perceptions, and lay the foundations for children to undertake increasingly complicated cerebral endeavours, such as planning and organisation (Jurado & Rosselli, 2007; Pureza et al., 2011). These activities require individuals to think ahead to map out the necessary steps in advance, and then tackle them in a logical, strategic and efficient manner (Best et al., 2009).

Evidence indicates that executive functions are associated with a range of important and desirable outcomes for children and adults. Executive function development, for example, displays positive correlations with school readiness, physical health and academic performance among learners (Dias & Seabra, 2015; Wiebe et al., 2014; Zelazo et al., 2013). Conversely, compelling research by Moffitt et al. (2011) following a birth cohort study of 972 children in Dunedin, New Zealand, found that poorer executive function, particularly self-control, between the ages of 3 and 11 predicted lower earnings, substance dependency and criminal convictions 30 years later, even after controlling for measures of socio-economic status (SES) and intelligence. Similarly, their analysis of longitudinal data on British twins corroborates the Dunedin findings and reveals poorer outcomes for the sibling with lower self-control, notwithstanding the shared family background.

Precise formulations of the nature, constituents and relationship of executive functions nevertheless remain subject to debate. Indeed, "[t]he diversity of definitions for executive functions support the complexity of this concept that encompasses many integrated components" (Jurado & Rosselli, 2007, p. 226). There is, however, general consensus that they broadly comprise three inter-related but discrete components, namely working memory, inhibitory control and cognitive flexibility (Diamond, 2006; Miyake et al., 2000). Attention is also sometimes cited as pivotal to the operation of the overall central executive system, but arguably comprises an interconnected function that cuts across and draws upon the three core components rather than a separate aspect itself (Garon et al., 2008).

Working memory involves more than simply holding information in mind over a brief period of time. It requires that individuals simultaneously perform one or more mental functions, perhaps manipulating the concepts to explore different interrelations, deconstructing components and reconstituting them in new ways (Diamond & Ling, 2016; Dias & Seabra, 2015; Engel de Abreu et al., 2014; Jacob & Parkinson, 2015; Sarsour et al., 2011). Working memory, which typically relies more on the dorsolateral prefrontal cortex, plays an important role in enabling learners to understand the passage of time, relate preceding events to the current circumstances and draw on them for future-oriented actions (Atance et al., 2015; Diamond, 2013). In this way, working memory serves as an important foundation for building longer-term explicit and implicit memory to foster a core base of knowledge, facts and skills (Abadzi, 2016).

Inhibitory control serves quite a different set of cognitive purposes. It enables learners to regulate and control their behaviour, delay gratification, and resist temptations, distractions and irrelevances to stay disciplined and focused on the task at hand (Cartwright, 2012; Clark et al., 2013; Diamond, 2016). Individuals with greater inhibitory control are better able to suppress conditioned or prepotent responses to react immediately or impulsively, and thereby capable of consciously choosing the most appropriate course of action (Bellaj et al., 2016; Dias & Seabra, 2015; Jacob & Parkinson, 2015; Sarsour et al., 2011).

Interpretations of cognitive flexibility vary considerably and defy any simple or universal definition. Narrow conceptualisations emphasise the ability to shift attention between different mental sets, or on the same task but using multiple rules or dimensions (Dick, 2014; Hofmann et al., 2012; Jacob & Parkinson, 2015; Yeniad et al., 2014). Ionescu (2012) meanwhile frames it as a *property* or *characteristic* of mental processes rather than an independent skill or competency in its own right. Diamond (2014), however, appears to offer the most comprehensive formulation. She describes cognitive flexibility as including "creatively 'thinking outside the box,' seeing anything from different perspectives, and quickly and flexibly adapting to changed circumstances" (p. 206). This interpretation thereby incorporates notions of shifting or switching, both the focus of individuals' attention and their outward behaviour in response to the evolving demands of a situation (Cartwright, 2012; Jurado & Rosselli, 2007; Vandenbroucke et al., 2016). It also draws on imagination and creativity to access other perspectives and conceive novel approaches beyond the immediate here and now (Carlson & White, 2013).

Notwithstanding definitional debates, cognitive flexibility appears to play an important role in scaffolding the development of skills for adaptability: "[c]ognitive flexibility is critical in a changing world. It is essential for adaptability and for the creativity that comes from being able to see things in new or different ways" (Davidson et al., 2006, p. 2067). It also supports the acquisition of more sophisticated competencies like reasoning and planning, as depicted in Figure 2.1 (Diamond, 2006, 2014; Diamond & Ling, 2016). Problem solving in particular engages all three executive functions: working memory to recall and manipulate salient information; inhibitory control to ignore irrelevant details and focus on the target task; and cognitive flexibility to draw on different perspectives and shift between possible solutions (Jacob & Parkinson, 2015). Without every component, learners may therefore struggle to attain the higher-level skills necessary for them to improve their and their families' lives.

Despite their apparent importance, there has been minimal research to date on cognitive flexibility and executive function development among children living in lower-income countries (Dias & Seabra, 2015; Obradović & Willoughby, 2019). For many years, most studies focused exclusively on learners in Europe and North America. Recently, however, this situation has been changing with an increasing body of evidence and data on children in Asia, Latin America and sub-Saharan Africa (Bellaj et al., 2016; Cook et al., 2019; Fink et al., 2012; Hermida et al., 2015; Holding et al., 2018; Howard et al., 2020; McCoy et al., 2015; Obradović et al., 2016; Talwar et al., 2011; Tarullo et al., 2017; Willoughby et al., 2019; Zuilkowski et al., 2016). Indeed, two new measures for assessing young children's development in such contexts have been launched, namely the Measuring Early Learning Quality and Outcomes (MELQO) and the International Development and Early Learning Assessment (IDELA), both of which include measures for executive function, specifically working memory and inhibitory control, but not cognitive flexibility (Pisani et al., 2015; UNESCO et al., 2017).

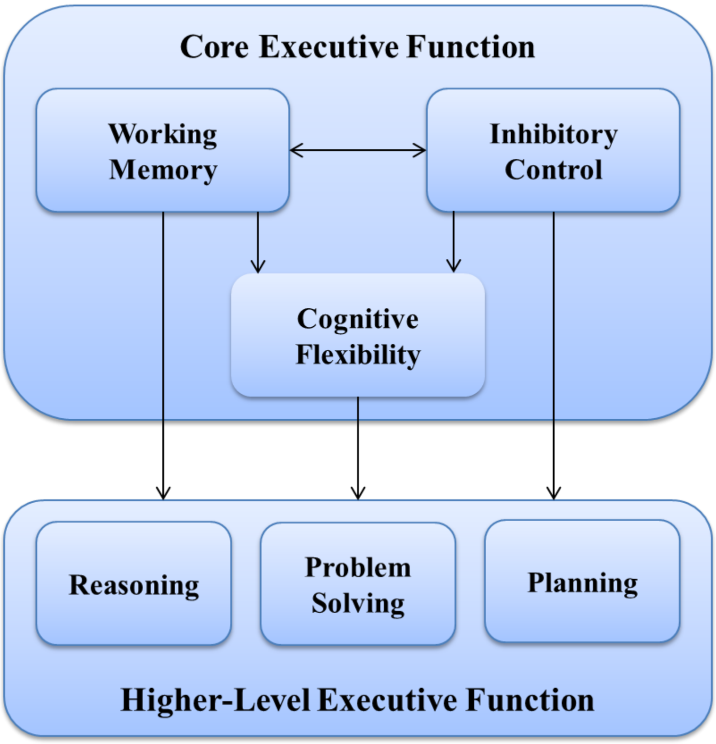


Figure 2.1 - Framework of Executive Functions
(based on Diamond (2014), p. 207, Figure 7.1)

The historic dearth of data from low-income countries is particularly significant for two main reasons. First, the literature currently available on the home, school or other factors that shape and influence executive functions among 'normal'[2] children is based on a small and unrepresentative sample of learners worldwide (Wolf & McCoy, 2019). This means that accepted 'knowledge' regarding executive function trajectories only provides a partial and skewed picture of child development. Second, an increased understanding of learners' early executive functions could offer valuable insight on how best to close the global learning gap. Given the evidence concerning links between executive function and academic achievement, albeit largely from higher-income countries, greater developmental research among disadvantaged children could help to improve outcomes for the estimated 250 million learners who fail to master basic literacy and numeracy even after 4 years of formal education (Rose, 2015; UNESCO, 2014).

[2] A considerable body of literature from Europe and North America also focuses on the development of executive functions among children with autism and attention deficit-hyperactivity disorder.

Beyond these gaps, there is also the issue of context specificity and translatability, whether or not executive functions hold the same meanings and operate similarly across such drastically different settings. The arguments outlined above regarding the role of cultural values and norms in defining and fostering complex cognitive skills may equally apply to learners' more basic psychological processes (Abadzi, 2006; Dias et al., 2013; Kraak et al., 2006; Tikly et al., 2003). However, Obradović and Willoughby (2019) point at growing global evidence on executive function validities, predictors and biological bases to argue that they represent a "culturally universal set of cognitive skills" (p. 227).

In reality, the scope for transferability will likely depend on the executive function involved and the characteristics of the particular setting. For example, thinking flexibly and 'outside the box' may be interpreted and articulated differently in societies that emphasise standardised conduct, conformity and deference to authority, compared with those that promote creativity and originality (Bayley, 2015; Tikly et al., 2003). Likewise, cultural attitudes towards self-restraint and expectations of children may dictate and shape perceptions around appropriate levels of inhibitory control. In a study of behavioural regulation across several Asian countries and the United States, Wanless et al. (2011) suggest that American parents may be more encouraging to their children in terms of participation and engagement with older family members. By contrast, Talwar et al. (2011) report disciplinary practices and attitudes among teachers and parents in two West African schools and the delicate balance they seek to strike between achieving immediate compliance and fostering longer-term self-control among pupils.

Notwithstanding the limitations of the existing literature and the complexities of cultural influence, considerable research reveals a range of factors that directly affect children's cognitive flexibility and wider executive function development, which are discussed in greater detail below. However, efforts to ascertain the extent of their relative impact presume that executive functions can be meaningfully monitored and reliably measured. In fact, assessing executive functions raises a host of challenges that complicate their measurement.

2.2.2 Measuring Executive Functions

First, the interrelated nature of executive functions gives rise to the problem of 'task impurity' which can undermine construct validity and test reliability. As Jurado and Rosselli (2007) note, "[t]he ongoing controversy regarding the formal definition of executive functions and the existence of a central executive construct makes the accurate assessment of these functions seem to be an impossible task" (p. 218). The complex dynamics between working memory, inhibitory control and cognitive flexibility are also often seen to confound attempts to isolate their specific dimensions, conceptually, operationally and indeed from non-executive processes, and thereby impede their effective measurement (Best et al., 2009; Dick, 2014; Jacob & Parkinson, 2015). Nevertheless, such challenges are not insurmountable and a seminal study by Miyake et al. (2000) clarified the unitary-but-diverse nature of executive functions.

Specifically, Miyake et al. (2000) assessed 137 American college students on a comprehensive battery of experimental measures, comprising multiple component tests to tap each executive function as well as more complex tasks like the Tower of Hanoi and Wisconsin Card Sorting Test. They then used confirmatory factor analysis to examine the extent of overlap between the latent variables and found three separate but moderately correlated executive functions. A χ^2 difference test further revealed that a three-factor model provided a significantly better fit than using *independent* factors and that, while separable, there is some degree of commonality and underlying mechanism across the three executive functions.

Beyond task impurity, there are difficulties associated with measuring the same skills across wide age groups and along very different developmental trajectories (Barnett et al., 2015; Zelazo et al., 2013). For example, certain tests may be too challenging or inappropriate for young children, requiring literacy or numeracy that may not yet have been learnt. Similarly, assessments may use different indicators to gauge performance at different age points, such as the Hearts and Flowers Task which measures shifting scores based on a combination of response time, accuracy and efficiency, depending on the age of the participant (Diamond et al., 2007; Huizinga et al., 2006; Yeniad et al., 2014).

Further, and in line with the challenge of attributing benefits to cognitive competencies as described above, there is the perennial difficulty of not just recognising correlation but also ascribing causation. This issue varies depending on the circumstances of the relevant explanatory factor. In the case of relations *between* separate executive functions, there may be strong causal evidence of one function clearly scaffolding the development of another (Miyake et al., 2000). Nevertheless, correlations between a child's executive functions may be mediated by a host of observed and unobserved interactions and influences, as discussed in greater detail below (Sarsour et al., 2011; Vandenbroucke et al., 2016).

Regarding the assessment of cognitive flexibility specifically, there are particular issues concerning the type of cognitive flexibility under investigation, and the nature of the measure involved. First, Podjarny, Kamawar and Andrews (2017) seek to distinguish between *switching* and *concurrent* cognitive flexibility and emphasise the need for clarity on which is being assessed. They recognise the value of flexible thinking to shift between different dimensions of the same stimulus at different times, but argue that sometimes one must entertain the multiple perspectives together simultaneously. They cite the example of a child requested to fetch a red marker from a crafts box who must concurrently consider both the shape and the colour of the item.

To explore the distinction, Podjarny et al. (2017) compared the performance of 107 pre-schoolers on a new measure for concurrent cognitive flexibility, the Multidimensional Card Selection Task, against their scores on the Dimension Change Card Sort, a more traditional assessment for (sequential) cognitive flexibility. Finding a positive but imperfect correlation between the two, their research adds nuance to the analysis by Miyake et al. (2000) to suggest that "cognitive flexibility is not composed of a single skill; rather, it consists of multiple conceptually related skills" (Podjarny et al., 2017, p. 204).

Beyond types of *cognitive flexibility*, Jacques and Zelazo (2001, 2005) highlight the difference between types of cognitive flexibility *measure*, namely between deductive and inductive assessments. In the former, participants are informed by which dimensions they should sort the stimuli, whereas in the latter they must identify the relevant characteristics for themselves. Inductive measures therefore create an additional requirement for respondents to infer or abstract the salient dimension, which can increase the complexity of analysis in the event of poor performance.

Notwithstanding the various considerations and challenges inherent in measuring executive functions, many tools and instruments are available and widely used to triangulate cognitive development and explain the different factors at play (Barnett et al., 2015; Cornoldi et al., 2015). These factors are described below and can be broadly categorised as maturational, environmental and educational.

2.2.3 Maturational Factors

A sizeable body of neuropsychological research examines the maturational factors that affect the development of children's executive functions. In this respect, maturation relates to both changes in learners' brains and the effects of ageing over time, although the two are invariably linked (Lehto et al., 2003). Specific findings draw clear relationships between cerebral growth and, for example, children's ability to manipulate information or control their behaviour (Best et al., 2009; Diamond, 2006; Sarsour et al., 2011; Zelazo et al., 2013). In particular, executive function appears connected to a neural circuit in the lateral prefrontal cortex, a large region anterior to the precentral sulcus (Diamond & Lee, 2011; Wiebe et al., 2014). Evidence shows that the prefrontal cortex "follows a particularly protracted timetable to maturation, unlike other brain regions that mature earlier in childhood" (Best et al., 2009, p. 182). Indeed, certain parts of the frontal lobe only achieve full levels of development fairly late in adolescence or early adulthood (Diamond, 2002, 2016; Jurado & Rosselli, 2007).

Research further indicates that executive functions follow different developmental trajectories, with young brains especially neuroplastic and malleable during growth spurts in their pre-school years, and then again during middle childhood from ages 6 to 12 (Carlson & White, 2013; Dias & Seabra, 2015; Sarsour et al., 2011; Vandenbroucke et al., 2016; Zelazo et al., 1997, 2013). Inhibitory control emerges first among the core functions, showing growth from infancy, improvement during pre-school years and generally reduced changes in later periods (Best et al., 2009; Wiebe et al., 2014). Working memory and cognitive flexibility, on the other hand, appear around the pre-school age (3 to 6) but then develop into adolescence (ages 12 to 15), or even later (Cartwright, 2012; Cragg & Chevalier, 2012; Jurado & Rosselli, 2007).

Cognitive flexibility in particular shows a prolonged growth trajectory with some evidence indicating that it continues to improve between 15 and 21 years (Huizinga et al., 2006). While the development of each executive function invariably impacts on the others, Diamond (2016, 2014) suggests that cognitive flexibility is especially reliant on the other two core functions. From a conceptual perspective this would appear to make sense as "[t]o shift mental sets or see something from different perspectives, you need to activate and maintain a new set or perspective in working memory and you need to inhibit the set or perspective that was just being used" (Diamond, 2016, p. 15).

In this regard, studies in several contexts corroborate the contribution of working memory to cognitive flexibility development (Dick, 2014; Engel de Abreu et al., 2014; Miyake et al., 2000; Pureza et al., 2011). Most recently, however, the research by Podjarny et al. (2017) adds important nuance to indicate that *concurrent* cognitive flexibility relies on children's working memory to hold multiple dimensions in mind simultaneously, while *switching* cognitive flexibility draws more on inhibitory control to deactivate one mind-set and sequentially shift to another.

Indeed, the relationship between cognitive flexibility and inhibitory control is less than straightforward, and possibly even inverse. A study by Blackwell, Chatham, Wiseheart and Munakata (2014) revealed apparent trade-offs between 6-year-olds' abilities to inhibit distractions and switch between tasks. Specifically, the children who could switch effectively displayed *worse* response inhibition and were more easily distracted than the learners who perseverated, and vice versa. Related to this are the switch costs and additional cognitive demands associated with any change. These typically comprise reductions in accuracy or extra time required to achieve a switch, and can vary depending on the rules or dimensions involved (Davidson et al., 2006; Ellefson et al., 2006; Pope et al., 2019).

Finally, there are some suggestions that certain aspects of cognitive flexibility could actually *decrease* with age and education. Improved knowledge could render learners increasingly dependent on previous or traditional patterns of solutions (Bilalić et al., 2008; Ionescu, 2012). Likewise, conceptions of object permanence or functional fixedness may impede older children from thinking 'outside the box' (Defeyter & German, 2003). Obviously, these claims hardly justify arguments against formal education but they do highlight cognitive flexibility's complex developmental trajectory.

2.2.4 Environmental Factors

Evidence indicates that environmental factors, particularly SES and family life, also play a major role in the development of children's cognitive flexibility and other executive functions (Bellaj et al., 2016; Cartwright, 2012; Diamond, 2016; Jacob & Parkinson, 2015). Cultural influences, beliefs and customs may likewise shape the processes through which executive functions develop and are applied in everyday life (Sarma & Thomas, 2020). However, the prolonged plasticity of the prefrontal cortex which offers an extended opportunity for learners' growth also translates into a protracted period of heightened sensitivity to adverse environmental conditions (Clark et al., 2013).

Children's executive functions can be affected by a wide range of immediate household factors. These include: the family wealth and organisation (living with one or both parents); parental education; caregiver stimulation, responsiveness and availability (emotional, or to help with homework); nutrition; maternal smoking during pregnancy; and access to learning resources in the home or through 'enrichment' activities (hobbies and visits to museums and libraries) (Berkes et al., 2019; Clark et al., 2013; Fitzpatrick et al., 2014; Grantham-McGregor et al., 2007; Jurado & Rosselli, 2007; Sarsour et al., 2011; Stonehouse, 2014; Vandenbroucke et al., 2016; Walker et al., 2011). Stress is also negatively associated with executive function development, whether it arises in the child, flooding the prefrontal cortex with dopamine, or the parent, harming their interactions within the family (Blair, 2016; Diamond, 2016).

Environmental factors can affect different executive functions to varying degrees and at different times. Likewise, household circumstances can interact in complex and dynamic ways to mitigate or exacerbate the impact of SES on a child's cognitive development. A study by Sarsour et al. (2011) found from a sample of 60 American 8-12 year-olds that "[a]fter controlling for age and single-parent status, family SES explained 24% of the variance in cognitive flexibility, 9% of unique variance in working memory, and 8% of variance in inhibition skills" (p. 126). Similarly, they discovered that low-SES children from single-parent households displayed worse executive functions than those living with both parents, while increased parental responsivity and sensitivity to the child mediated the correlation between family SES, working memory and inhibitory control. Language behaviours, whether bilingualism or caregivers' rich use of vocabulary, can also moderate otherwise challenging contexts or offer benefits in terms of improved learning settings (Bellaj et al., 2016; Bialystok & Viswanathan, 2009; Cartwright, 2012; Jacques & Zelazo, 2005; Lohndorf et al., 2019; Meltzer & Bagnato, 2010; Pureza et al., 2011).

Overall, environmental conditions play a major role in children's executive function development. These relationships arguably highlight the importance of ensuring quality early learning experiences for disadvantaged children to give them the best initial opportunities and reduce the risk of a widening skill gap (Clark et al., 2013; Diamond, 2016).

2.2.5 Educational Factors

Various aspects of education, not least formal schooling, targeted interventions and curriculum design appear to offer more direct contributions to the development of children's cognitive flexibility and other executive functions. Indeed, the relationship is well documented and "there is substantial evidence that academic achievement and measures of executive function are correlated – both at a single point in time and as predictors of future achievement, and for a variety of different constructs and age groups" (Jacob & Parkinson, 2015, p. 18). Similarly, there are suggestions that executive functions, and specifically cognitive flexibility, may better predict school readiness and academic achievement than intelligence quotient scores (Blair & Razza, 2007; Traverso et al., 2015; Vitiello et al., 2011; Zelazo et al., 2013).

As noted above, however, understanding the dynamics of the different associations or attempting to ascribe causality represent complex endeavours. The majority of related literature emphasises the role of executive functions to support and scaffold school performance, rather than the reverse (Baker et al., 2010). This could perhaps reflect the historic focus of research on schools and learning environments in higher-income countries, which typically have greater traditions and availability of pre-primary education than most lower-income countries (Dias & Seabra, 2015). This would also obviate the need to explore the role of schools in fostering executive functions in such settings on the basis that learners would have passed through kindergarten and nursery, and therefore already had some opportunity to practise their executive skills and develop their school readiness.

There is likewise evidence to suggest that cognitive flexibility specifically improves during formal schooling, but this could occur through a variety of plausible mechanisms (Best et al., 2009; Romine & Reynolds, 2005). One possibility is that the transition to primary school forces children to adjust, building their ability to adapt quickly between different tasks and environments (Chevalier et al., 2010; Yeniad et al., 2014). Another is that schooling refines working memory and inhibitory control, by learning content and following rules, and these in turn support improvements in cognitive flexibility. A third possibility is that children attend school during a stage when their prefrontal cortex is naturally going through a period of pronounced growth so as to foster greater cognitive flexibility. Indeed, any one or a combination of these possibilities could be the case.

Testing practices and emerging reading skills could also mediate the relationship between schooling and children's cognitive flexibility. Taking tests demands that pupils shift back and forth between subjects and topics, learning to apply their knowledge to new problems or in different contexts (Meltzer & Bagnato, 2010). Several studies also highlight an important association between the development of children's basic literacy, their executive functions generally and their cognitive flexibility specifically. Cartwright (2008) emphasises the reciprocal interaction between nascent reading skills and executive functions, culminating in "the ability to manage multiple mental representations, and to do this flexibly" (p. 3). More recently, she and others identified the unique contribution of cognitive flexibility to American learners' reading fluency and comprehension (Cartwright et al., 2019). However, while there is evidence that cognitive flexibility and reading are mutually supportive, the same complexities described above apply in terms of understanding the specific causal mechanisms (Abadzi, 2006; Homer & Hayward, 2008).

Beyond standard schooling practices, there is some evidence that school-based interventions can yield benefits for cognitive flexibility and other executive functions. Interventions designed to stimulate and promote learners' active thinking, creativity and working memory appear to have been successfully deployed in contexts including Brazil, Italy and Spain (Cornoldi et al., 2015; de Acedo Lizarraga et al., 2010; Dias & Seabra, 2015). In some cases, the initiative entailed computerised cognitive training and games, in others it involved a programme of activities to supplement the main school curriculum, such as *Tools of the Mind* (Blair, 2016; Diamond et al., 2007; Diamond & Ling, 2016).

Targeted support for teachers has also been shown to increase pupils' executive functions. Longitudinal research by Wolf (2019) with over 2,400 children in Ghana found that a 1-year school-randomised teacher-training programme[3] resulted in statistically significant and sustained gains in the learners' cognitive flexibility. Play-based approaches can likewise foster all three executive functions, and concurrently. Diamond and Lee (2011) describe how "[d]uring pretend play, children must inhibit acting out of character, remember their own and others' roles, and flexibly adjust as their friends improvise" (p. 961).

[3] Such programme comprised 8 days of formal workshops and six in-classroom coaching sessions, in both cases spread throughout the school year.

Personal wellbeing arguably plays an important role in executive function development. Loneliness, sadness and poor health are known to impair cognitive growth, and conversely physical exercise, sport and martial arts such as Tae Kwon Do show benefits for executive function and cognitive flexibility in particular (Diamond & Lee, 2011; Diamond & Ling, 2016). In sport, the situation is constantly shifting and players must adapt quickly and automatically. Martial arts similarly can help to build concentration and discipline. However, skills and competencies, physical or mental, need to be continuously challenged and pushed near their limits to achieve ongoing improvements (Abadzi, 2016). Also, there is little scope for transfer of gains between functions and "[p]eople improve on the skills they practice [*sic*] and that transfers to other contexts where those same skills are needed, but people *only* improve on what they practice [*sic*]; improvement does not seem to transfer to other skills" (Diamond & Ling, 2016, p. 36, original italics).

Research therefore suggests that different educational interventions, both classroom-based and more holistic, can help to scaffold children's executive functions and cognitive competencies. However, as discussed above, the majority of studies focus on learners in higher-income countries, far removed from the realities of poverty and deprivation in their lower-income counterparts. Similarly, the reach of interventions is limited to participants in a relatively small number of tailored and often costly initiatives. In response to these constraints, and the worldwide demand for improved skills, many countries have introduced competence-based curricula in schools to attempt to meet their national workforce needs (Tedesco et al., 2014).

These curricula typically advocate more collaborative, interactive and innovative approaches to teaching and learning (Amadio, 2013; Tedesco et al., 2014). They draw on conceptions of skills and learning outcomes that are decontextualised and predefined, however, evidence regarding their efficacy remains very limited. Studies across six African countries rather highlight the *challenges* in implementing such curricula and report hasty and poorly conceived reforms, inadequate preparations for the (re)training of teachers, insufficient allocation of resources and ineffective coordination with assessment practices (Gauthier, 2013; Musonda, 1999). Cunningham (2018) also highlights the risks of overloading curricula and teachers in systems that are already fragile and poorly equipped. Overall, the results do not undermine the potential contribution of competence-based approaches *per se*, but certainly emphasise the need for careful preparation, planning and resourcing in their implementation.

The lack of compelling data on the impact of competence-based curricula is not, however, deterring further countries from introducing them. Rwanda is one such country, and therefore forms the focus of the next section.

2.3 The Rwandan Context

2.3.1 A Country on the Move

Recent years have seen Rwanda celebrated as a beacon for African development in a period of post-conflict reconstruction (Straus & Waldorf, 2011). Since the 1994 genocide, the country has witnessed a period of rapid financial growth and social progress with a clear vision for long-term transformation from an agrarian subsistence economy into a knowledge-based society (Ansoms, 2011; Knutsson, 2012). However, the path is largely uncharted and Rwanda continues to rank low in terms of human development (157 out of 189 countries) (United Nations Development Programme, 2019). Despite considerable foreign aid and a rising private sector, the government must manage tensions between deep poverty and high-flying national ambition. For now, Rwanda finds itself "engaged in a difficult balancing act, attempting to simultaneously bring about post-genocide national reconciliation *and* global economic competitiveness" (Knutsson, 2012, p. 185, original italics).

With few natural resources and a young and burgeoning population[4], Rwanda's future will need an educated workforce with appropriate skills for not just employment, but also enterprise and job creation (Bamwesiga, 2013; Pells et al., 2014; Rwanda Education Board (REB), 2012). The country aspires to become an information and communications technology (ICT) hub for Africa, while the *7 Years Government Programme: National Strategy for Transformation 2017-2024* highlights the need to create 214,000 jobs each year to accommodate new workforce entrants (Republic of Rwanda, n.d.; Rubagiza et al., 2011). As part of this strategy, and further to an existing competence-based approach for adult training, the government adopted a new curriculum in February 2016 to explicitly nurture key skills and aptitudes in learners across *all* levels of education (Kuboja & Mbarushimana, 2016; Mushimijimana, 2016; Republic of Rwanda Ministry of Education (MINEDUC) & REB, 2015).

[4] 43 per cent of people are under 15 and 54 per cent are younger than 20 (Abbott et al., 2015).

The new competence-based curriculum represents an opportunity for progress on numerous fronts. First, it provides a unified framework to promote the coherence, consistency and quality of Rwandan education across all schools (REB & MINEDUC, 2015). Second, the curriculum seeks to address the pressing economic situation by building Rwandan human capital and inculcating the skills necessary to apply learning to real-life problems and settings. Third, it advocates the importance of core personal and social values for citizens to live together peacefully, not least integrity, self-reliance, equality, tolerance and respect for others (MINEDUC, 2015).

The curriculum expressly moves beyond a focus on basic competences[5], such as literacy and numeracy, to foster a wide range of learning outcomes. Indeed, it builds on Bloom's taxonomy to discuss the need for higher-order thinking skills including reasoning, theorising and hypothesising (REB & MINEDUC, 2015). Specific provision is also made for nurturing transferable 'generic' competences, such as creativity, innovation and problem solving, which "will engender adaptability in young people so that they are prepared for an uncertain future" (REB & MINEDUC, 2015, p. 19). However, the curriculum remains in the early stages of its implementation and any results are yet to be seen.

2.3.2 Rwandan Education and Skills Development

In terms of education progress and indicators, the picture is less promising. Despite achieving gender parity and claims of near-universal primary enrolment, more children may in fact be out of school than formal statistics would suggest (Williams, 2016a). This may be due, at least in part, to teachers inflating pupil figures so that their schools receive larger capitation grants.

Within classrooms, many children are overage, and repetition and drop-out rates remain high (Sabates et al., 2010). In 2010, only 17.2 per cent of children attained their Primary 6 leaving certificates and more recent data highlight widening completion inequalities, more than a 30-per-cent difference, between learners from the poorest and wealthiest quintiles (Abbott et al., 2015; Rose et al., 2017). A study by Williams, Abbott and Mupenzi (2015) further found that at least some pupil absences could be attributed to the 'hidden costs' of schooling, with children

[5] There is some debate around the difference between 'competence' and 'competency', for example that the former emphasises performance ability against a set standard while the latter refers to wider behavioural skills (Kuboja & Mbarushimana, 2016). However, the curriculum and therefore this report use the terms largely interchangeably.

being sent home for failing to have the correct equipment or to pay supposedly voluntary parent-teacher association fees.

Regarding learning, evidence suggests that Rwandan pupils are continuing to experience major difficulties with early grade reading and mathematics (RTI International, 2012). Research across a northern district found that learners could only identify about a third of alphabet letters at the end of Primary 1 (Friedlander & Goldenberg, 2016). Despite considerable resource allocations, the education system continues to face significant challenges, pressures and tensions with many teachers working double shifts, poorly motivated or absent from their classrooms (Abbott et al., 2015). Many schools are still contending with the consequences of rapid policy changes, not least the expansion to 12 years of basic education and the introduction of English as the primary language of instruction (Pearson, 2014; Samuelson & Freedman, 2010; Williams, 2016b, 2020).

At present, little is known about the cognitive competencies or executive functions of Rwandan children, over and above their basic literacy and numeracy[6]. The most recent and credible evidence among Rwandan *learners* however relates to the acquisition of critical thinking skills among university students. An empirical investigation by Schendel (2015, 2016) randomly sampled and tested cross-sections of first and fourth year undergraduates in multiple disciplines at the country's three main universities. The results in general found no significant effect on scores in critical thinking tasks, which suggested that students may not be improving such skills during their higher education careers.

In reality, however, few Rwandan children go on to attend university not least because so many drop out before completing even primary education (Abbott et al., 2015; Ilie & Rose, 2016). Beyond cost, many reasons previously given for non-attendance emphasise a lack of interest in schooling which neither captures learners' attention nor appears relevant to their daily lives (Musker et al., 2014). The importance of *early* education that confers more practical and immediate benefits is therefore evident. Indeed, improved cognitive competencies like creativity, innovation and problem solving among primary-aged children could help not just to

[6] The only study of executive function in Rwanda, at least published in international journals, concerns the relationship between post-traumatic stress disorders and *adult* genocide survivors' cognitive competencies (Blanchette et al., 2019).

enhance the relevance and application of schooling, but also thereby improve wider interest and attendance.

To summarise, this chapter has outlined the potential benefits of skills for adaptability, introduced cognitive flexibility as an important underlying function and highlighted knowledge gaps concerning children's executive functions in lower-income contexts. Each of these holds particular significance for Rwanda, a country which has already made significant strides since the 1994 devastation and which aims to continue such progress by building a solid base of human capital. The next chapter therefore sets out the research questions and describes the methodology used to conduct the study.

CHAPTER 3 – METHODOLOGY

3.1 Research Focus and Questions

The preceding chapter highlighted the dearth of data on children's executive functions in low-income countries. In Rwanda, the knowledge gap is particularly pressing, given the country's new competence-based curriculum and aspirations to leapfrog towards middle-income status (Tikly et al., 2003). Research to understand and enhance cognitive flexibility specifically could confer socio-economic advantages through increased creativity, problem solving and innovation among communities and the forthcoming workforce. This study therefore explored the development of Rwandan children's cognitive flexibility within formal primary education. In particular, the inquiry sought to answer the following research questions (RQs):

RQ1: How can Rwandan pupils' cognitive flexibility be measured during the course of their public primary education and what factors are associated with its development?

RQ2: How does the cognitive flexibility development of Rwandan public primary school pupils relate to their other cognitive competencies?

RQ3: What are the perceptions and attitudes of Rwandan public primary school teaching staff regarding the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?

RQ4: What practices or behaviours are Rwandan public primary schools using to enable the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?

The research focus presumed that Rwandan pupils' cognitive competencies can be assessed and fostered, possibly through factors including classroom processes, practices and behaviours, which in turn are shaped by the perceptions and attitudes of the academic staff in those schools.

This chapter therefore sets out the methodologies and techniques used to answer these questions. Initial sections outline the philosophical paradigms and theoretical frameworks that underpinned the research, before introducing case study as the overarching approach to generate appropriate data. The chapter proceeds to describe the sampling strategy and different methods used, before concluding with a discussion on the ethical issues that arose during the study.

3.2 Philosophical Paradigms

The research questions entail certain beliefs and assumptions around the nature of reality (ontology) and how humans can understand and learn about it (epistemology). First, they presume the existence of an objective physical universe with observable and measurable phenomena external to individual human experience (Taber, 2013). Second, they suppose that we can discover and access independent truths and general laws through science and research.

Historically, such assumptions would accord with a realist ontology and a positivist epistemological paradigm (Cohen et al., 2015; Guba, 1990). In positivism, educational and psychological constructs like learning and cognitive flexibility are knowable or can be made knowable through empirical inquiry (Johnson et al., 2007; Mason, 2002). However, this approach arguably ignores the more subjective aspects of human behaviour and interaction. Indeed, positivism is typically contrasted with the interpretivist paradigm which emphasises a more relative and situated understanding of knowledge and reality. Such tradition suggests that "[m]eaning does not exist in its own right; it is constructed by human beings as they interact and engage in interpretation" (Robson, 2011, p. 24) .

The research therefore adopts a *post*-positivist stance between the two opposing paradigms. Although formulations of post-positivism vary, the study presumes the existence of an objective external reality but recognises a critical plurality of perspectives and the limitations of any one individual's bias and experience to access and know any unambiguous truths (Cohen et al., 2015; Phillips, 1990; Robson, 2011). Hanson (1958) illustrates the influence of different vantage points by imagining two astronomers witnessing the same sunrise. While one perceives the sun as rising up from the horizon, the other observes the earth rotating away to expose the sun. Further, there may be patterns of human behaviour, particularly within education, that are socially constructed and exist above and beyond the natural world (Taber, 2013). Learning, education and schools as institutions can be observed and investigated as external phenomena but are also personally experienced and meaningfully interpreted as relevant knowledge in a social world (Mason, 2002).

The values or axiology implied within research can similarly affect its design and implementation. As noted in the preceding chapter, executive functions and cognitive flexibility specifically might offer a range of economic and sociological benefits to learners and their communities alike. More generally, education can be seen as furthering numerous important and shared social values, not least building human capital for economic growth and prosperity, facilitating individuals to realise their personal capabilities, and addressing power imbalances and social injustices, particularly in a post-colonial setting (Sen, 1999; Tikly & Barrett, 2011; Tikly & Bond, 2013). Further, Heckman (2006, 2008) emphasises the value of *early* educational processes to build basic competencies and individual dispositions such as commitment, motivation and perseverance.

Indeed, as highlighted above, Rwanda's new competence-based curriculum recognises the multiple roles of and values implied within schooling, in particular to build a skilled and competitive workforce, and to promote peace, inclusion and social cohesion (MINEDUC, 2015). This study therefore aimed to reflect these stated objectives, while also acknowledging the significance of educational quality to achieve the desired learning outcomes. Quality arguably represents a key characteristic and aspiration for any school system and a powerful determinant for pupils' cognitive development (Hanushek & Woessmann, 2008). The next section therefore examines different models for education quality and links them with principles of child psychology to provide a theoretical framework for the research.

3.3 Theoretical Framework

Interpretations of 'quality' in international education have gained growing prominence in recent years. On the one hand, quality considerations have become increasingly relevant as investments to expand schooling systems have failed to achieve the expected economic returns (Hanushek & Woessmann, 2008). On the other, efforts to prescribe and promote improvements raise causal and conceptual issues when "[r]eadily measurable cognitive outcomes shift from being privileged indicators of quality to defining quality" (Tikly & Barrett, 2011, p. 4).

In terms of inputs, an early formulation by UNESCO (2005) highlighted the numerous child, school and contextual factors that affect learning and mapped them into a model for educational quality. These included teaching methods, assessment practices and the use of different learning materials. More recently, studies have similarly reiterated the need for an effective alignment between teacher training, assessment and the applicable curriculum (Westbrook et al., 2013). However, Tikly (2011) criticises the UNESCO model as presenting a 'one size fits all' approach to education quality. He also suggests that:

> it is problematic to assume a linear relationship between inputs, processes and outputs of education that is often implied by an input–output model... Rather the inter-relationships between learner characteristics, enabling inputs, educational processes and outcomes are complex, multi-dimensional and vary according to context (Tikly, 2011, p. 6).

Instead, Tikly (2011) advocates for the model proposed by the Implementing Education Quality in Low-Income Countries (EdQual) initiative. This framework identifies three particular contexts, namely the policy environment, the school, and the home and community as important to promote and enable learning. Core components, such as pedagogy and curriculum, sit within the spheres, and he further emphasises the processes needed to convert the right mix of inputs into desirable outcomes and the different dynamics across their various interactions.

The EdQual model appears to offer a more adaptable solution for understanding and planning for educational quality compared with earlier formulations. Indeed, the prescribed components of the policy environment broadly correspond to the structural organisation of the Rwanda Education Board (REB)[7], the government department with responsibility for increasing and assuring the quality of Rwandan education. However, the EdQual framework could arguably go further to reflect the complexity of inter-relationships between processes, context and the characteristics of individual learners. In particular, the approach represents a largely top-down explanation and neglects the wide gulf that often exists between high-level policies and the reality of classroom practices. Indeed, pupils only experience educational reforms through the more immediate filters of family, school and community, and Bronfenbrenner's bioecological systems theory therefore provides a complementary and more child-centred basis for exploring learners' cognitive development.

[7] Details of the REB operating structure can be found at http://www.mineduc.gov.rw/agencies/rwanda-education-board/.

Initial formulations of the theory highlighted the influence of one's setting within "[t]he ecological environment…conceived as a set of nested structures, each inside the next, like a set of Russian dolls" (Bronfenbrenner, 1979, p. 3). First, children grow and develop within a *microsystem*, such as their home or school, in which they actively engage with other participants, such as parents, teachers and peers (Bronfenbrenner, 1979, 1986; Bronfenbrenner & Crouter, 1983). Children, however, also move between different microsystems and the interaction between these systems, such as parent-teacher meetings, are reflected in the *mesosystem*. Beyond the child's direct experience, external environments or *exosystems* can indirectly affect their development. These might include the parents' workplace, circle of friends and social network, which can enrich or disrupt a child's home life. At a higher level, the prevailing culture, policies and norms of a society shape behaviours within the *macrosystem*, while the *chronosystem* charts temporal patterns and shifts in a person's life and the larger sociohistorical context.

Later evolutions of the theory brought into focus the key role of *proximal processes* and individual characteristics, and highlighted how they influence, mediate and moderate ecological factors through the Process-Person-Context-Time model (Bronfenbrenner & Morris, 2006; Feinstein et al., 2004). Proximal processes comprise interactions between the learner and his or her environment which involve engaging in an activity on a regular basis over an extended period of time (Bronfenbrenner & Morris, 1998). Such activities need to become increasingly complex, and can extend to include wider categories of participants or entail solitary exchanges with symbols or objects. Personal traits or qualities, such as temperament, skills and age, can similarly affect how more remote and distal factors influence an individual's development.

The bioecological theory therefore offers a sophisticated model for identifying the personal and contextual factors that shape human development, and for analysing the nuanced interactions and synergies between them. Nevertheless, applying the framework to a school or educational setting to explore cognitive flexibility development is not necessarily straightforward. Indeed, Tudge, Mokrova, Hatfield and Karnik (2009) indicate that to examine every aspect of the theory, each process, characteristic, system or setting, would necessarily entail a large and very complex study. Children also habitually and legitimately move between different school microsystems, from class activities to whole-school assemblies, which can affect their development (Rudasill et al., 2018).

Notwithstanding these challenges, the EdQual model and bioecological theory together offered a compelling framework through which to explore Rwandan children's cognitive flexibility development. Figure 3.1 provides an outline of the adapted framework, which draws on policy and school-based factors from the EdQual model and places them into a series of nested systems. Assessment practices, teacher and classroom activities, and the use of resources and materials comprise the proximal processes through which children repeatedly and progressively engage to enhance their learning outcomes. Meanwhile, the mesosystem is expanded to capture important interactions between proximal processes and the distal factors in the exosystem.

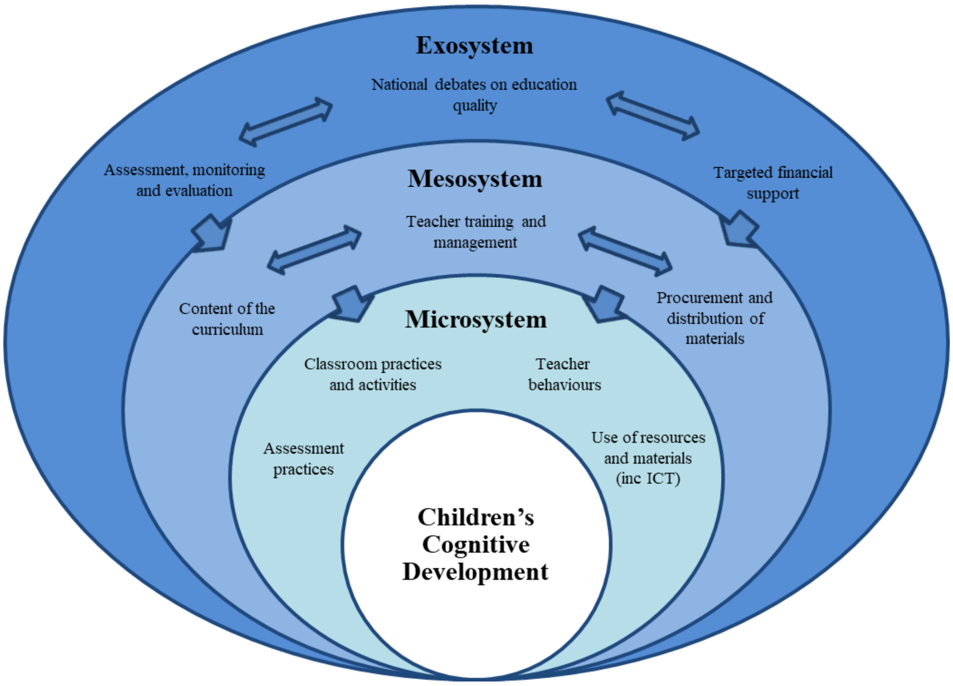


Figure 3.1 - Adapted Theoretical Framework

The adapted framework thereby provided a practical guide for exploring how formal primary schooling enables the development of Rwandan children's cognitive flexibility. In particular, the model balanced the top-down nature of the EdQual framework with the more child-centred, bottom-up bioecological systems theory. The next section therefore turns to the research methodology and the various techniques used in collecting appropriate data.

3.4 Methodological Approach

Applying the theoretical framework to explore the relationship between primary schooling and cognitive flexibility suggested a multi-faceted approach in conducting the research. Indeed, the bioecological model permits the integration of data from numerous disciplines, such as the distal factors of political economy with the proximal processes of psychology and education (Feinstein et al., 2004). Further, the post-positivist paradigm that underpinned the study implied a need for different methods that seek to both access evidence of an objective truth, while interpreting and understanding the experiences and perceptions of those involved in its construction.

3.4.1 Mixed Methods

Mixed-methods research has become an increasingly recognised and prominent approach for investigating complex issues in the social sciences. Johnson, Onwuegbuzie and Turner (2007) suggest that it represents a middle ground between more extreme quantitative and qualitative viewpoints, and accommodates multiple perspectives by adopting an emerging third paradigm. However, the precise definition of 'mixed methods' remains contested. On the one hand, Greene, Caracelli and Graham (1989) propose a broad formulation as research including "at least one quantitative method (designed to collect numbers) and one qualitative method (designed to collect words), where neither type of method is inherently linked to any particular inquiry paradigm" (p. 256). On the other hand, Venkatesh, Brown and Bala (2013) argue that research is only truly mixed where both types of data are integrated to draw meta-inferences from the findings. They contrast it with 'multi-methods' research which uses numerous means of data collection within the same philosophical tradition.

Recognising its post-positivist stance, this study adopted a mixed-methods approach using the wider definition. Specifically, the research combined quantitative and qualitative methods to maximise completeness, minimise the limitations of each paradigm, and ensure a rich and detailed understanding of cognitive flexibility in Rwandan schools (Creswell & Creswell, 2017; Venkatesh et al., 2016). In so doing, the study considered children's cognitive development as an independent and external object of inquiry, but also acknowledged my own scope to influence the research, intentional or otherwise.

3.4.2 Case Study

Within mixed methods, case study further provided an appropriate and suitably versatile methodology through which to undertake the research. Yin (2009) describes a case study as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 18). Case studies are often preferred to answer complex 'how' or 'why' questions and can be used to explore, describe and explain phenomena rigorously in a naturalistic setting, rather than seeking to isolate them from their usual environment (Cohen et al., 2015; Yin, 1981).

Studies may examine one or multiple cases but each case must be clearly identifiable and sufficiently bounded from other similar or related possible units of inquiry (Taber, 2013). For instance, cases can be physically, geographically or temporally separated from one another, and may comprise people, objects, systems or institutions (Stake, 1995). In the current study, the cases were four Rwandan primary schools, and specifically the formal and organised educational activities, practices and processes conducted by each school for the purposes of its pupils' learning[8]. Further, cases can contain multiple internal levels or embedded subunits of analysis (Yin, 2009). In the Rwandan schools, these comprised pupils, principals[9] and subject-based classroom teachers.

In accordance with the post-positivist tradition and mixed-methods approach, case studies permit, indeed encourage, researchers to engage with multiple sources of evidence. Data may be quantitative, qualitative or a combination of both, and collected through interviews, observations, questionnaires and other appropriate methods (Yin, 1981). Through a mixed strategy, case studies can examine and confirm patterns between phenomena, as well as explore the nuances to gain a deeper and more complete understanding of the relationships concerned (Johnson et al., 2007).

Nevertheless, Tight (2010) construes the flexibility of case studies as a methodological weakness. He suggests that the term is now so widely and ambiguously used that many types of research could be deemed a 'case study'. Likewise, establishing the validity and reliability of case studies presents a conceptual challenge.

[8] This definition acknowledges that some school activities may take place off the premises, also that not every action or practice on school property (for example, bullying) necessarily relates to or promotes pupils' learning.
[9] Other titles used within schools included 'head teacher' and 'director', but for the purposes of this thesis, 'principal' and 'head teacher' are used interchangeably.

3.4.3 Validity and Reliability

Typically, as the investigation of a single instance, the findings of a case study may offer little relevance or insight for different contexts. For all their depth and rigour, case studies arguably illustrate, explain or interpret a phenomenon in a unique environment with little generalisability or meaning in alternative settings (Cohen et al., 2015). Certainly, engaging with validity and reliability in the context of a case study requires a different approach from analysing the results of a representative quantitative inquiry.

Yin (2009) highlights the importance of evaluating the construct, internal and external validities when determining the quality of a case study. First, construct validity concerns the extent to which the construct has been identified, articulated and operationalised in light of prevailing theories and literature to examine the phenomenon under investigation. Internal validity, on the other hand, relates to the conditions and causal relationships *within* the case, whether the data accurately describe and explain the relevant interactions. Finally, external validity pertains to "the degree to which the results can be generalized [*sic*] to the wider population, cases, settings, times or situations, i.e. to the transferability of the findings" (Cohen et al., 2015, p. 186). Critically, case studies are not intended to represent the wider population and offer only theoretical but not statistical generalisation. Even in multiple-case studies which provide greater analytical power, the replication logic in choosing cases must be distinguished from the sampling logic used in conducting surveys, which requires identification of the entire universe of possible respondents (Yin, 2009).

Cohen et al. (2015) further highlight the relevance of cross-cultural validity when undertaking international research. They ask whether features and phenomena are sufficiently similar across the particular contexts, and query the feasibility of using instruments created and validated in one country to conduct research in a second country. Another issue concerns whether the researcher works with the constructs, terms and definitions from his or her own culture, or draws on those arising from the respondents themselves (Hammersley, 2006; Stake, 1995).

Beyond validity, the reliability of case studies represents an additional, important consideration (Yin, 2009). In this context, 'reliability' concerns the consistency and dependability of the research, and whether repeated data collection would achieve similar results over time, or using different participants, observers or investigators. In psychological studies, this can warrant multiple measures to assess the construct at different intervals, not least because "[b]ehavioural change cannot be equated with developmental change" (Bronfenbrenner & Crouter, 1983, pp. 381–382).

Case studies can address issues of validity and reliability in a range of ways. These can include 'member checking' findings with respondents, using multiple questions to access and test the interpretation of a particular construct, triangulating the results through different methods or multiple cases, and by providing a 'thick' description of the context to enable informed readers to apply pertinent findings to their own settings (Cohen et al., 2015; Johnson et al., 2007; Taber, 2013). Indeed, while validity can arguably never be *fully* achieved, these considerations and solutions informed much of the current research approach and design, as detailed below.

3.4.4 Research Approach

As indicated above, this case study adopted a mixed-methods strategy to collect both qualitative and quantitative data to answer the research questions and explore cognitive flexibility development within Rwandan basic education. In accordance with the theoretical framework in Figure 3.1, public primary schools were selected as microsystems within a multi-case study, and chosen for their intrinsic value and interest following Rwanda's introduction of a competence-based curriculum (Stake, 1995; Yin, 2009).

Notwithstanding the limitations noted above regarding generalisability and extrapolation, case studies that investigate multiple sites are typically considered to be more robust (Creswell, 2012; Herriott & Firestone, 1983). They offer improved external validity and an opportunity to draw conclusions across both similar and different cases. Stake (2006) recommends a minimum of four cases, while Yin (2009) advises choosing each case carefully "so that it either (a) predicts similar results (a *literal replication*) or (b) predicts contrasting results but for anticipatable reasons (a *theoretical replication*)" (p. 54, original italics).

In light of these considerations, the case study investigated four schools chosen from two Rwandan districts. In each district, I sought to pair schools according to geographic proximity and academic performance. Regarding the former, schools situated relatively near to one another were chosen to both enable comparisons in a similar locale and reduce variations between them that could arise from differences in resourcing or community-based factors. In terms of achievement, I used scores from national examinations to rank institutions and thereby identify one higher- and one lower-performing school. This structure was used to elicit common characteristics or differences in schools' approaches, and included poorer-performing schools to be more instrumental and representative of the many lower-performing public schools across Rwanda (Yin, 2009). Full details concerning the selection of cases and sampling of research units are set out in section 3.5, but Figure 3.2 provides an overview of the main structure.

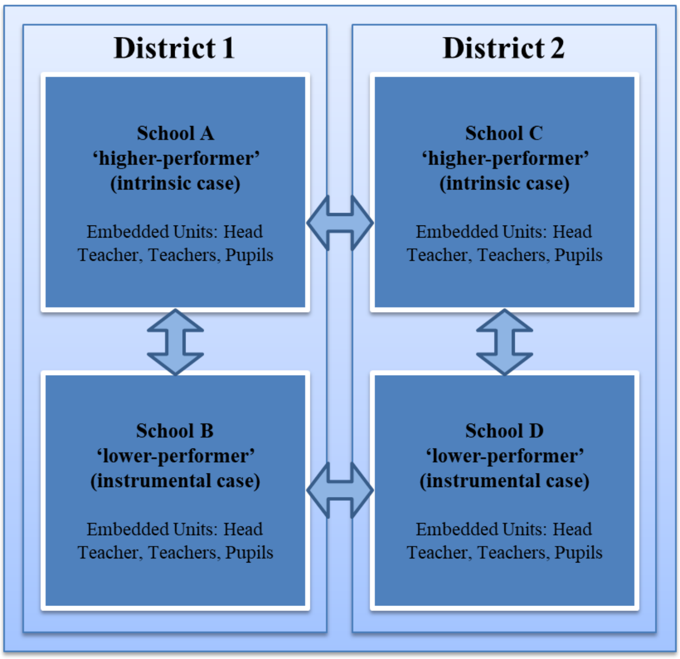


Figure 3.2 - Multiple Case Study Structure

Regarding education level, data available in Rwanda during the design of the research suggested that *primary* education provides most children with their only formal schooling experience (Abbott et al., 2015). Given evidence around the importance of early educational investments and notwithstanding doubts on the *actual* levels of Rwandan enrolment, primary schooling seemed to offer the best opportunity to support the development of children's cognitive flexibility, and to learn about its relationship with formal education (Heckman, 2006, 2008). This was achieved by using a multilevel mixed design (Teddlie & Tashakkori, 2009). Within each school, different methods were used to collect both quantitative and qualitative data at different levels of the institution and points in the learning process.

By way of summary, these methods first involved assessing children in Primary 1 and 4 classes on their cognitive flexibility, operationalised through their performance on both switching and shifting tasks. Primary 1 pupils were chosen on account of being right at the start of their formal schooling, while the Primary 4 learners had typically completed at least 3 years of primary education. Following the assessments, the children were also measured on several wider competencies and surveyed to gather information on their prior educational experiences and different aspects of their home life.

Next, I observed a range of classes in each school, again focused on the Primary 1 and 4 cohorts. I then interviewed the school principals and selected teachers to ascertain their perspectives and experiences of fostering cognitive flexibility and its related competencies. Full details of the assessments, observations and interviews are described below, while the analytical methods used for the different types of data are outlined at the start of each results chapter. Figure 3.3 also shows the methods used at each level, while Figure 3.4 maps out the overall research design.

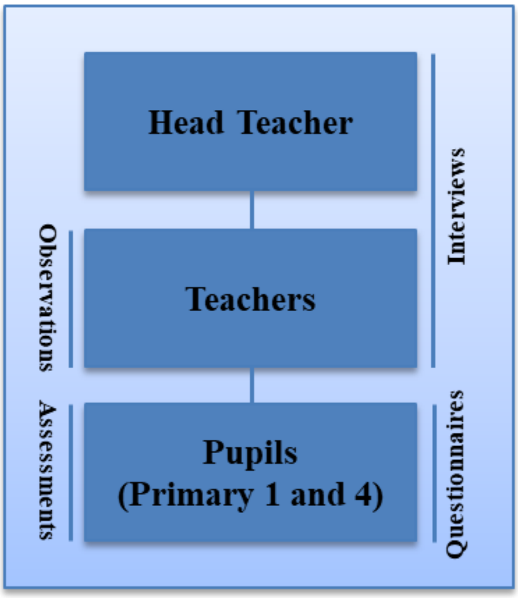


Figure 3.3 - School Levels, Respondents and Research Methods

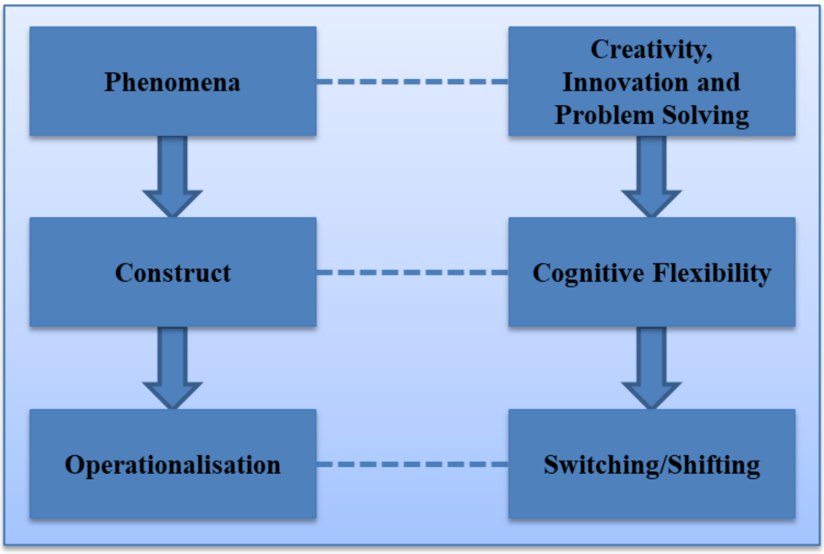


Figure 3.4 - Overall Research Design

In terms of sequencing, all assessments and surveys were concluded with pupils before I started the lesson observations. Similarly, teachers were only interviewed once their observations were complete. I took this approach to minimise the risk that teachers changed their classroom practices in response to the interview discussions, or sought to prepare their pupils to participate in the assessments. Figure 3.5 shows the order of the key activities and phases throughout the study.

Quantitative data from the pupil assessments and questionnaires were used to address the first (RQ1) and second (RQ2) research questions. Specifically, RQ1 entailed plotting their cognitive flexibility scores and comparing differences between class samples within and across the four case schools. In parallel, RQ2 involved examining pupils' performance on other assessment measures to explore trends against differences in cognitive flexibility. In each case, although the samples remained fairly small and unrepresentative, such methods were used to generate *nomothetic* data to capture information on groups of different school pupils.

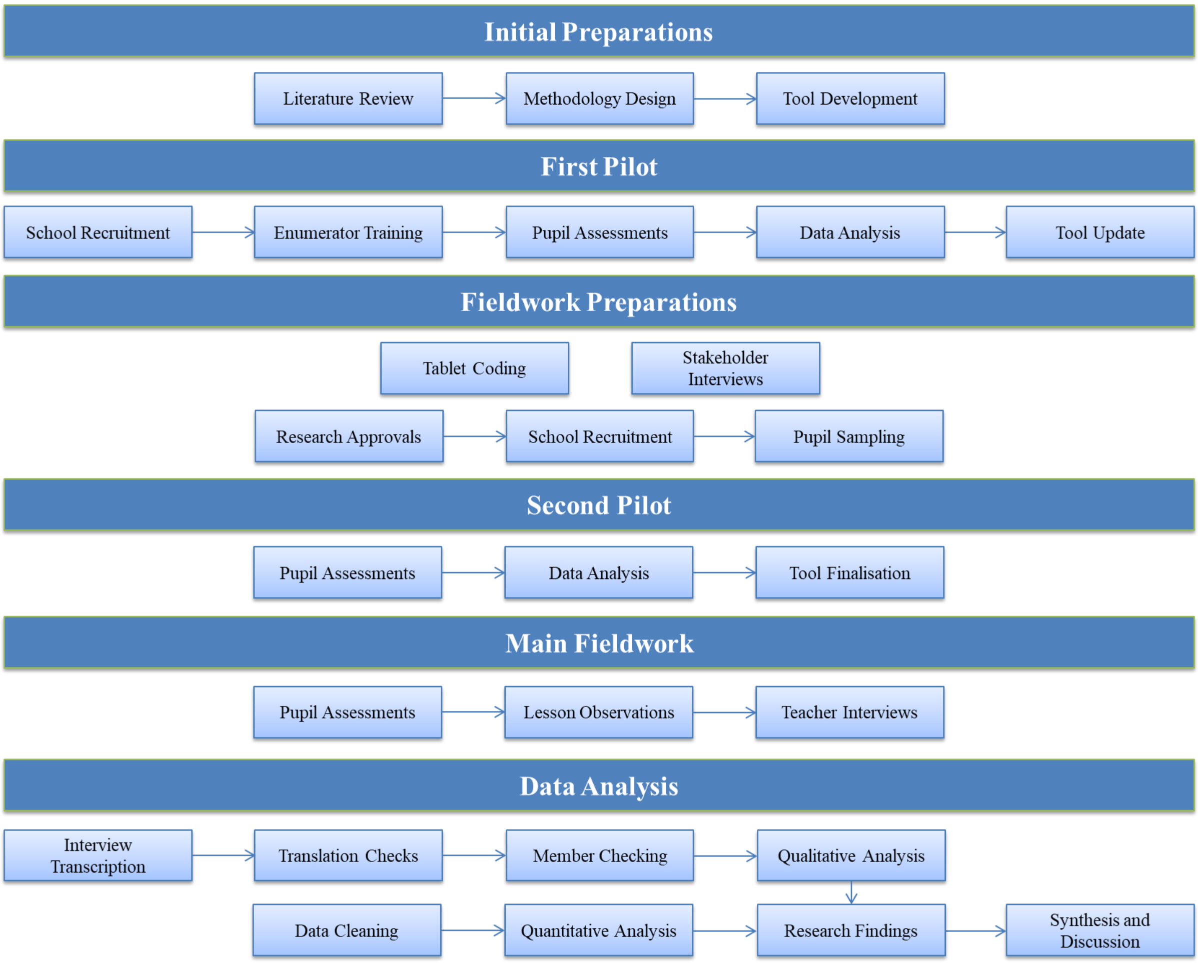


Figure 3.5 - Key Activities and Phases

By contrast, the qualitative data from the interviews with teaching staff offered *idiographic* insight into individuals' understandings and attitudes, to thereby address the third research question (RQ3). Similarly, the interviews were used to reveal reported school practices and behaviours *perceived* as fostering children's cognitive flexibility, whether through proximal processes, implementation of the new competence-based curriculum or otherwise (Taber, 2013). These perceptions were then triangulated and complemented with classroom observations of what teachers were *actually* doing to answer the fourth research question (RQ4). Table 3.1 below matches the data collection methods and different respondents with the research questions.

Table 3.1 - Research Questions, Data Type, Methods and Respondents

Research Question	Data Type	Methods	Respondents
1. How can Rwandan pupils' cognitive flexibility be measured during the course of their public primary education and what factors are associated with its development?	Quantitative	Assessments, questionnaires	Pupils
2. How does the cognitive flexibility development of Rwandan public primary school pupils relate to their other cognitive competencies?	Quantitative	Assessments, questionnaires	Pupils
3. What are the perceptions and attitudes of Rwandan public primary school teaching staff regarding the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	Qualitative	Interviews	Head Teachers, Teachers
4. What practices or behaviours are Rwandan public primary schools using to enable the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	Qualitative	Interviews, observations	Head Teachers, Teachers

3.4.5 First Pilot

To inform, improve and refine the research design, I undertook two pilots, the first during a 3-week visit to Rwanda in June-July 2017 and the second in February 2018. Additional details of the pilots including the resultant analyses are set out in Appendix 1.

The purposes of the 2017 visit were twofold. First, I wanted to trial several measures of executive function in Rwanda, given the dearth of studies on African children's development and the lack of instruments validated in a comparable context. Second, I needed to undertake a preliminary mapping of the education system, recognising the impact of high-level trends and debates in the exosystem on pupils' learning, as shown in Figure 3.1. Similarly, there was relatively limited information publicly available on the new competence-based curriculum and its implementation.

The pilot took place in a private primary school on the outskirts of Kigali. All learners in the Primary 1 (26 pupils) and 4 (25 pupils) classes were assessed by two trained female Rwandan enumerators who were experienced with testing children and had been contracted by Laterite Africa, a respected research firm operating in Kigali. Before taking part, each child was briefed on the purpose of the exercise and notified of his or her rights of withdrawal and non-participation. Data from the assessments provided valuable insight on which measures were appropriate for the Rwandan pupils and suitable for inclusion in the main fieldwork, details of which are set out in section 3.6.3 below. In addition to the assessments, I also observed three classes and interviewed three teachers, including the principal, to pilot my observation and interview schedules.

The system mapping meanwhile involved meeting with representatives from the REB and six development partners who worked closely with the Rwandan government. In each case, the discussions were arranged with assistance from my supervisor at the University of Rwanda[10] and covered general education trends, curriculum implementation and other learning inputs identified in the theoretical framework. On my return to Rwanda in 2018, I also met with four further officials from the REB and MINEDUC before commencing the main fieldwork. These conversations served to provide fresh insight on the latest system developments, as well as to explore perceptions, attitudes and opinions among key Rwandan policymakers. Such perspectives were important given the *post-positivist* nature of the study, and to increase both construct and cross-cultural validities.

3.4.6 Curriculum Implementation

As outlined in the preceding chapter, in 2016 MINEDUC introduced a competence-based curriculum to facilitate improvements in the quality of education and thereby equip Rwandan learners with more practical life skills (Ngendahayo & Askell-Williams, 2016). As part of this, the REB also implemented training for teachers to use the curriculum effectively, strengthened processes around the procurement of textbooks and materials, and started to reconceptualise the need for and role of assessment (Kanamugire, 2016; Mushimijimana, 2016).

Conversations with the different stakeholders revealed that teacher training for the new curriculum had been designed based on a cascade model, and that this had entailed the creation of several new positions and key responsibilities. At the outset, the REB had trained approximately 140 National Subject Trainers, who had in turn started instructing over 3,000 District Master Subject Trainers (DMASTs) (MINEDUC, 2015b; REB, n.d.). The DMASTs were then intended to train school subject leaders (typically seven per primary school) who

[10] In accordance with Rwandan visa requirements, all academic research must be conducted under the auspices of a supervisor at the University of Rwanda. In addition to providing practical support and access, this collaboration offered further, invaluable insight into cultural issues related to cognitive flexibility, creativity, innovation and problem solving.

would work with principals to deliver standardised and bespoke school-based in-service training for staff, depending on their professional needs.

However, at the time of the discussions, progress beyond the initial trainings had been slow, and Rwanda faced many of the same challenges described for competence-based curricula in other comparable contexts (Gauthier, 2013; Makunja, 2016; Musonda, 1999). Although school-based training appeared to be underway in some more proactive districts, the widespread cascading of knowledge and skills from teachers to their colleagues had been stalled by insufficient budget allocations (conversations with education professionals, 2017). School staff were reportedly eager to adopt the new approach but there was limited understanding at numerous levels of what 'competence-based learning' really meant and how it could be delivered. Many teachers still struggled to use English as a medium of instruction and school-based mentors had their own teaching loads, and therefore limited time to support improved language or pedagogy with others.

Beyond teaching, the production and distribution of textbooks had also proved difficult. The textbooks themselves were reportedly of variable quality and not necessarily tailored to learner-centred methods. Similarly, there were delays with dissemination, with one book shared among five pupils, far short of the one-book-per-child target. Nevertheless, initiatives by some of the larger multi- and bilateral donors were working to address many of the most pressing challenges.

3.4.7 Field Preparation

In addition to the policymaker meetings, January and February 2018 provided an important opportunity to make essential practical preparations for undertaking the fieldwork. Throughout the preparations, and indeed the wider research, I was supported by Laterite, whose staff and contractors helped to strengthen the cross-cultural validity of the study through access to Rwandan attitudes, insights and perceptions on cognitive flexibility and how it could be nurtured (Cohen et al., 2015).

First, I submitted applications to and liaised with appropriate personnel to secure the necessary approvals to conduct the research. These included representatives from the University of

Rwanda, MINEDUC and two executive district offices in the province of Kigali. Copies of the final approvals are included in Appendix 2.

Second, I visited 16 schools within the two districts to recruit participants for the case study. In each case, I was accompanied by a field coordinator who was able to explain the background and purpose of the research to the school management in Kinyarwanda. Full details of the final sampling are set out in section 3.5 below.

Third, I worked with local interpreters to translate key documents such as the information sheets, consent forms and pupil assessment instructions into Kinyarwanda. This involved several stages where the texts were first translated into Kinyarwanda and then back-translated into English by a different interpreter to check the quality of the translation (Brislin, 1970). I then checked the back-translations in detail and discussed the intended purpose of the wording, as well as the errors and ambiguities, with the interpreter in person before he made the final corrections. Throughout the process, the focus was on the simplicity and intelligibility of the translation, rather than its word-for-word accuracy. For example, '*ibanga*' meaning 'secrecy' was used as there is no Kinyarwanda equivalent for the word 'confidentiality'.

Fourth, I converted the pupil assessments and questionnaires into coded format to enable the use of android tablets in the quantitative data collection. Specifically, I programmed the content in SurveyCTO software, which enabled the field staff to practise using the instruments in both Kinyarwanda and English.

Finally, I recruited and trained four enumerators to undertake the assessments and surveys with the primary pupils. As with the first pilot, the field staff were contracted through Laterite and comprised Rwandan women who spoke fluent English and had prior experience of conducting research with children. The team included both the field coordinator and one of the enumerators involved in the first pilot. Each enumerator participated in the week-long training which included an overview of the research and its purpose, and two days of instruction and practice in English before using the assessments on the tablets in Kinyarwanda. There was continuous two-way feedback throughout the process to ensure consistency, not least by clarifying the instructions in English, updating the programme coding and correcting the Kinyarwanda translations to use more accurate or child-friendly language. For example, the question around the number of books in a pupil's home was updated from using '*ufite*' to ‘*mufite*’ to indicate a plural, collective version of ‘you’, rather than asking about the books owned by the single, individual child.

3.4.8 Second Pilot

Following the classroom training and practice, the field team and I undertook a second pilot in a *public* primary school, which served several key purposes. First, given that the initial pilot was conducted in a private school, with a majority of children from wealthier Rwandan families, it was important to trial the instruments with pupils in public education who would be more representative of the participants in the main study. Second, the literacy assessments, one of the cognitive flexibility measures and some of the survey questions were not used in the first pilot and I needed to check that they offered sufficient variation within and across the grade cohorts. Further, the exercise provided additional training for the enumerators and an important opportunity to conduct a preliminary ‘dress rehearsal’ to refine the practicalities of undertaking the research *in situ* before moving to a larger scale (Barnett et al., 2015; Robson, 2011).

The pilot school was selected from one of the focus districts and fairly similar in key characteristics to the core case study schools. For example, it served over 1,500 primary learners and operated from a spacious landscaped campus. Many of the children reportedly came from the unplanned urban settlements that sprawled the neighbouring hillside and I was confident that the pupils at the pilot school would be from comparable backgrounds to those in the main research. In total, the enumerators assessed 34 children, split between the Primary 1 and Primary 4 cohorts.

With the methodology now outlined, the following sections outline the sampling approach, examine the data collection techniques in greater detail and describe the range of methods to generate both qualitative and quantitative data at the school level.

3.5 Sampling Approach

Selecting appropriate cases and respondents to participate in the research involved a multilevel mixed-methods sampling approach (Cohen et al., 2015; Teddlie & Tashakkori, 2009). I used both random probability and purposive non-probability sampling to identify the different units of analysis according to the level of the specific selection.

3.5.1 School Sampling

Primary schools were chosen through a five-stage process, involving the purposive selection of districts and then sampling according to school type, geographic location and performance on national examinations. Figure 3.6 provides an overview of the school sampling approach and the number of schools at each stage.

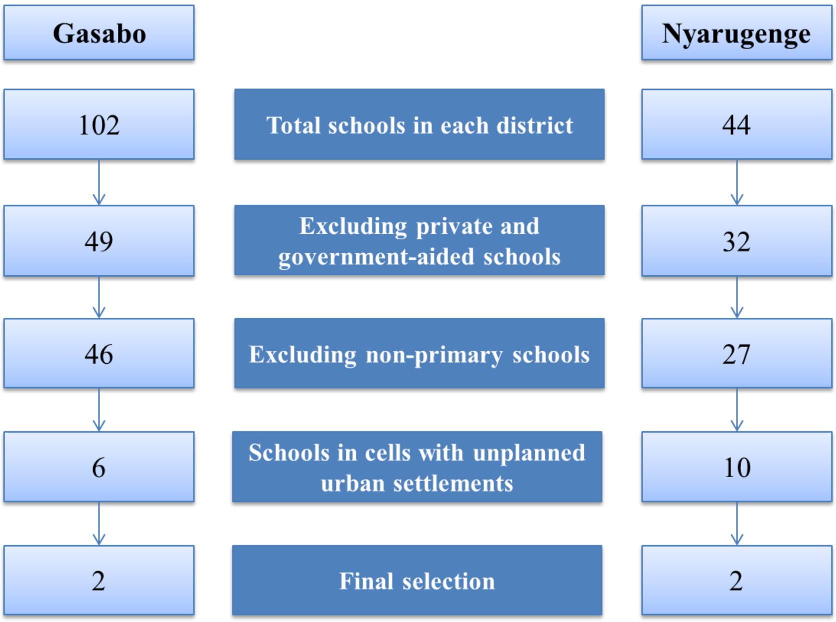


Figure 3.6 - Overview of School Sampling Approach

Statistics available at the time of the fieldwork showed that an estimated 84 per cent of Rwandans lived in rural areas (Abbott et al., 2015). For this reason, and to enhance the external validity of the research findings, I considered selecting schools and pupils from rural provinces only. However, as an *intrinsic* case study, and to maximise the likelihood of pedagogical variations between schools, I chose to focus on urban areas in the province of the Rwandan capital, Kigali[11].

Kigali province comprises three districts, Gasabo, Kicukiro and Nyarugenge, each of which contains a mix of rural and urban areas. There are nevertheless notable differences between

[11] Conducting the fieldwork in remote rural locations would have also drastically increased the cost of the research, as it would have entailed additional transport and accommodation expense.

them in terms of poverty and school quality indicators. Table 3.2 highlights several key statistics and, in light of these data, Gasabo and Nyarugenge were selected in the interests of equity and increasing the research's poverty focus.

Table 3.2 - Kigali City Districts by Poverty and School Quality Indicators

Kigali City District	Poverty Headcount Average	2016 Primary Pupil Enrolment	Average Pupils per Teaching Staff	Average Pupils per School Staff	Average Pupils per School	Average Pupils per Classroom	Average Pupils per Desk
Gasabo	28.26	93,240	51.60	46.18	847.64	69.43	4.07
Kicukiro	18.64	50,136	48.07	42.45	668.48	62.98	3.42
Nyarugenge	20.70	52,808	57.97	55.07	1,257.33	73.04	4.26

Sources: MINEDUC (2016), National Institute of Statistics Rwanda (2017)

In the second stage, I obtained the lists of all schools located in Gasabo and Nyarugenge districts[12], and excluded all privately run, government-aided[13] and non-primary schools. Despite conducting the first pilot in a private school, the research focused on the cognitive flexibility development of children in *public* education, not least because they are more likely to come from disadvantaged backgrounds. I further excluded schools without primary classes, the resulting list comprising a mix of *groupes scolaires* (combined primary and secondary) and *écoles primaires* (primary only).

In the third stage, I used unpublished Rwandan data to identify primary schools situated in cells[14] containing unplanned urban settlements. These were classified as villages where at least 90 per cent of the housing stock was deemed to be 'rudimentary' in a national census. The proximity of unplanned housing was treated as a proxy for poverty since these schools were likely to be serving poor urban children living in the area. To test this assumption, however, the field coordinator and I visited the different schools to meet with the principals, explain the purpose of the research and inquire about the student body, size and composition. We were also able to observe the condition of the school buildings, the local environs and the pupils themselves to assess whether or not the schools appeared to be serving children from low-income households.

[12] Such lists are available at https://education.rw/directory/schools.php.

[13] I briefly considered retaining the government-aided schools, such institutions being funded and run through the state system, but discussions with Laterite staff revealed that these schools enjoyed a particular historical legacy, which appeared to confer continuing benefits in terms of structures, management and performance.

[14] Local authorities in Rwanda are structured according to four tiers: districts (*akarere*), sectors (*umurenge*), cells (*utugari*) and villages (*umudugudu*).

In the fourth stage, I ranked the shortlisted schools based on their performance in recent national examinations (Kabarere et al., 2013). Again, these results were used as proxies for academic performance, recognising that such achievement could be unrelated to competencies like cognitive flexibility, creativity or problem solving. To do this, I obtained raw scores for Primary 6 leaving examinations from each district education office for the 2016 academic year, as the results for 2017 were still being finalised. I then ranked the schools based on pupils' average results and the proportions of children in each school that achieved division 1, 2 and 3 classifications.

In any case, attempting to rank or stratify schools using formal assessment data represented an imperfect solution, and Friedlander and Goldenberg (2016) note that such categorisation:

> may not reflect actual school quality. It is conceivable that low performing schools were actually schools that managed to retain more students and see them progress to P.6. The students in these schools might have a greater range of abilities, and hence the average score could be lower than schools in which struggling students…dropped out at greater rates (p. 35).

Recognising this limitation, I sought to balance these multiple factors in the final stage of the purposive school sampling approach. Drawing on the school visits and performance rankings, I selected one 'higher-performing' public primary school in each district from a cell that contained at least one unplanned urban settlement. Where there were schools with similar characteristics and rankings, I used satellite images from Google Earth to compare housing density to choose the school in what appeared to be the more disadvantaged area. Figure 3.7 provides an example image from Kigali and shows the different types of housing stock.

I then chose a nearby 'lower-performing' public primary school, where possible with an overlapping catchment area to minimise the social, political or community-based differences between them that could influence learning quality and outcomes (Mwaura et al., 2008). In both districts, the final selection was further constrained by several schools declining to take part, in some cases explicitly with a polite refusal, in some cases implicitly through the failure to return telephone calls and messages, and in other cases by requesting methodological changes that were incompatible with the study's design and objectives.

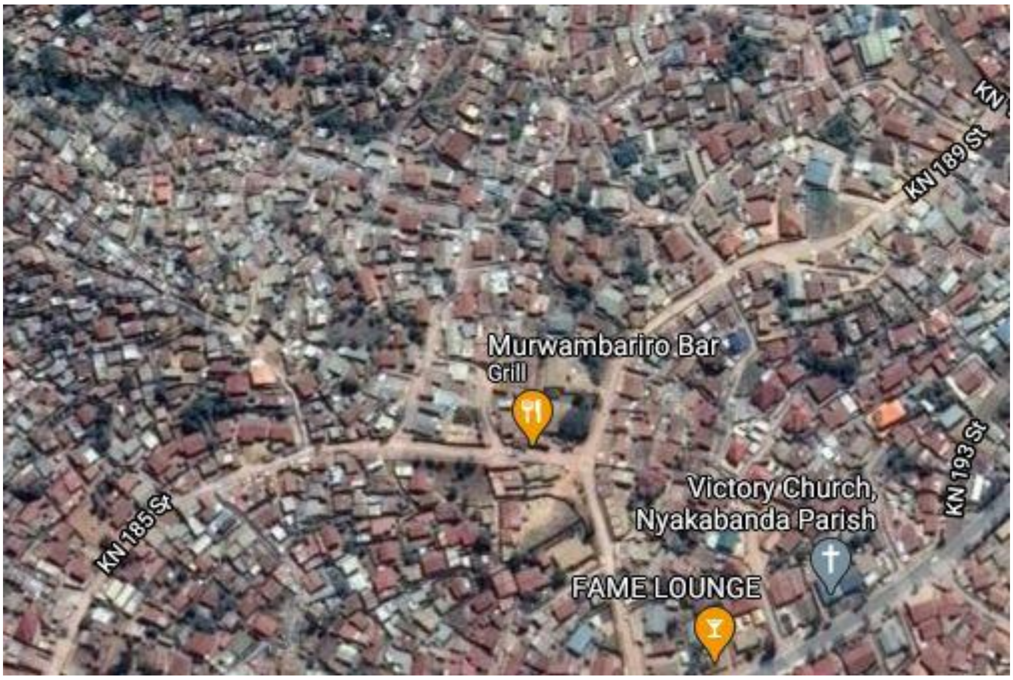


Figure 3.7 - Google Satellite Image of Kigali
Source: Google Maps[15].

Across the schools that agreed to participate in the research, there was a mix of similarities and differences. A detailed description of each school's key characteristics is important to build the overall validity of the study and to help readers assess the relevance of findings for other contexts (Cohen et al., 2015; Taber, 2013). Such descriptions are therefore set out in Appendix 3.

3.5.2 Teacher Sampling

In each school, I interviewed the head teacher and a selection of primary teachers, whose classes were also observed. Rwandan teachers typically teach by subject, rather than class, in which case I chose three teachers from the staff body in each school to represent the instruction of English, mathematics and social studies. English and mathematics were selected as 'high stakes' core subjects in the Rwandan curriculum, attainment in which is necessary for progression into higher levels of education. Social studies was chosen as a broader subject that potentially covers a range of topics, enables debates and discussions with multiple viewpoints, and therefore might offer valuable opportunities to foster children's cognitive flexibility.

[15] In particular, the image shows the difference between denser stock of smaller houses on the left, and larger houses and plots on the right. For reasons of anonymity, none of the participating case study schools appear in this image.

Specifically, I selected English teachers from Primary 1 classes and mathematics and social studies teachers from the Primary 4 academic staff. This choice was driven by practical and linguistic reasons, as at the time of the research English was used as the language of instruction from Primary 4 upwards (Edwards, 2019; McLean Hilker, 2011b; Pearson, 2014; Williams, 2020). I was thereby able to observe classes in both Primary 1 and 4 and follow the lesson delivery and content in English.

In some of the larger schools, there were parallel learning tracks and therefore multiple teachers for the same subject and the same grade. In such cases, I chose teachers who taught the greatest number of sampled pupils, the details of such sampling being described below. On one occasion, the chosen teacher declined to participate and the next teacher on the list was selected.

There was some mix of genders between respondents in the final sample but overall a strong prevalence of female teachers. In particular, the principals, English and mathematics teachers tended to be female, while the majority of social studies teachers were male. Table 3.3 provides a breakdown of the teachers by role, subject and gender. In total, I conducted 16 staff interviews across the four schools, thereby meeting and surpassing the minimum of 12 interviews usually required to achieve data saturation (Guest et al., 2006).

Table 3.3 - Teacher Respondent Profile by Role, Subject and Gender

Role/Subject	Male	Female	Total
Head teacher	1	3	4
English (P1)	0	4	4
Mathematics (P4)	1	3	4
Social Studies (P4)	3	1	4
Total	**5**	**11**	**16**

Source: Primary data, 2018.

3.5.3 Pupil Sampling

Sampling to select the pupils to participate in the research used student lists provided by the schools in either printed or electronic format. Each list contained the pupils' names, gender and either their age or year of birth.

Within the schools, the Primary 1 and 4 cohorts were divided into two equally sized groups as part of the logistical arrangements for double-shift timetabling. For example, Primary 1 pupils in classes A, C and E went to school on Monday mornings and Tuesday afternoons, while students in classes B, D and F attended lessons on Monday afternoons and Tuesday mornings. In each school, I wanted to sample an equal mix of pupils from both groups to account for any learning differences corresponding to the alternating attendance patterns.

For each primary cohort and group, I first sorted the pupils by age. According to national guidelines, pupils in Primary 1 should have been 7-8 years old, while those in Primary 4 were meant to be 10-11 years old (MINEDUC, 2016). However, as with the initial pilot, there were wide ranges within individual cohorts, and the oldest students were commonly 7 or more years older than the youngest pupils in the same classroom (Sabates et al., 2010). I therefore excluded children outside the prescribed ranges and randomly sampled a cross-section of 40 age-in-grade learners from both Primary 1 and 4 in each school, not least to minimise the confounding effects of an individual pupil being underage or overage[16].

This produced a total sampling frame of 320 children across the four schools[17]. I deemed this to be feasible in terms of time and cost, and also large enough to permit statistical analysis. Although the data were not intended to be representative or enable generalisation beyond the schools themselves, a sample size of 30 is widely considered to be the smallest number necessary to achieve a normal distribution under the central limit theorem, and so this was the minimum number of pupils sampled in each school cohort (Cohen et al., 2015; Field, 2009; Maas & Hox, 2005).

[16] As a further step in the pupil sampling, I asked the schools for the names of any children in their Primary 1 or 4 classes with serious diagnosed or reported mental or behavioural difficulties, such as autism or Asperger's Syndrome. At the time of the fieldwork, there were limited diagnostic tools for identifying such conditions among Rwandan children and so I relied on the reports from head teachers and school management. They reported having no such children in the relevant classes, save for one school which provided a list of children indicating their specific disability or developmental challenge. In such case, none of the children identified had been included in the sampling frame.

[17] While the pupil assessments were underway, some of the teachers indicated that the sampled children were absent or no longer attended the school. In such cases, I replaced the missing pupils with the next child or children on the list according to their randomly assigned number. In total, 33 pupils were replaced during the assessments using this approach.

3.5.4 Pupil Sample Overview

Overall, the quantitative data collection went largely to schedule and the fieldwork team assessed a total of 306 children. The slight reduction in sample size, down from 320, arose as a result of certain unexpected time constraints, however, 306 data points was already in excess of the minimum number required to perform the intended statistical analyses. The pupil sample was split evenly between Primary 1 and 4 classes and generally balanced across the four schools. Table 3.4 presents a breakdown by class, gender and age, while Table 3.5 also shows participation from the different schools.

Table 3.4 - Pupil Sample by Class, Gender and Age

Gender	Primary 1		Primary 4		Total
	7 Years	8 Years	10 Years	11 Years	
Boys	50	28	42	47	167
Girls	57	18	36	28	139
Subtotal	107	46	78	75	**306**
Total	**153**		**153**		

Source: Primary data, 2018.

Table 3.5 - Pupil Sample by Class, Gender and School

School	Primary 1			Primary 4			Total
	Boys	Girls	Total	Boys	Girls	Total	
School 1	20	19	39	17	22	39	78
School 2	19	21	40	29	10	39	79
School 3	22	17	39	22	16	38	77
School 4	17	18	35	21	16	37	72
Total	**78**	**75**	**153**	**89**	**64**	**153**	**306**

Source: Primary data, 2018.

The tables reveal two key features about the pupil sample. The first relates to the spread of children's ages across the two class cohorts. Table 3.4 shows that over two-thirds (107) of pupils in Primary 1 were at the correct age for the grade, being 7 years old at the start of the academic year, whereas at Primary 4 level children there was a much closer split between 10- and 11-year-olds (78 and 75 respectively). This difference hints at a slowing of pupils' progress as they advance through primary education and aligns with literature regarding rates of repetition and overage learners in Rwandan classrooms (Abbott et al., 2015; Sabates et al., 2010).

The second feature concerns the pupils' gender. The international evidence on children's cognitive flexibility development suggests few if any differences between boys and girls and consequently the sampling was not stratified according to gender (Bellaj et al., 2016; Willoughby et al., 2019). However, the randomisation of pupils produced a higher proportion of boys than girls at the Primary 4 level, 58.17 per cent (89) compared with 41.83 per cent (64). To interrogate this imbalance, I investigated the gender divide between the overall sampling frame and final pupil sample for each school to ascertain whether the difference could be ascribed to any systematic bias. The analysis revealed that the disparity was largely attributable to sampling in one school but that there was no evidence of any wider gender imbalance. In which case, and given the relevant international literature, I concluded that such difference should not have a material effect on the data analysis or resultant findings.

With the sampling approach and final samples now described, the next section focuses on the different methods used to collect data in accordance with the study's theoretical framework and post-positivist paradigm.

3.6 Data Collection

3.6.1 Interviews

As indicated above, I interviewed numerous school staff on issues including their perceptions, attitudes and practices regarding cognitive flexibility, and how it is or may be fostered in Rwandan classrooms. For each respondent, data was collected by means of a semi-structured interview. I chose to use interviews as a flexible and adaptable tool for exploring a wide range of research topics and in great depth (Bell, 2003; Pope & Denicolo, 1986). Semi-structured interviews in particular are organised around a set of open-ended predetermined questions, which can help to keep the discussions focused and increase overall reliability (Cohen et al., 2015; DiCicco-Bloom & Crabtree, 2006).

In terms of the interview *content*, I considered the participants unlikely to be particularly familiar or conversant with 'cognitive flexibility' as a specific psychological construct. Rather, the interview schedule and ensuing discussions referred to 'flexible' and 'adaptable' learners, being terms used in the competence-based curriculum (REB & MINEDUC, 2015). I also drew upon the Kinyarwanda terms '*guhanga udushya*' (creativity), '*ubudasa*' (innovation, or literally 'something different') and '*kwishakira ibisubizo*' (problem solving) as related concepts to convey my area of focus.

After a few warm-up questions, interviewees were asked about their perceptions and attitudes regarding the development of such competencies. In this context, 'perceptions' related to respondents' understandings and interpretations of these skills, while 'attitudes' concerned what they thought about them, not least the value of such competencies and their relevance to different learners and settings.

Participants were then questioned about practices and behaviours, both their own and those within the wider school microsystem, that may foster pupils' cognitive skills. By asking about practices, I drew on the theoretical framework to discern the proximal processes that take place at the school or classroom level, which could include involvement in pupils' extracurricular pursuits and formal or informal support for teachers through mentoring, trainings or peer collaboration. Meanwhile, the questions about behaviours sought to elicit details of individual habits and responses to certain situations, occurrences or opportunities, recalling patterns identified from the lesson observations where appropriate. Appendix 4 sets out the full interview schedule, while Table 3.6 below maps out the interactions between the research and interview questions.

Table 3.6 - Mapping of Research and Interview Questions

Research Question	**School Interview Schedule Questions**
RQ3. What are the perceptions and attitudes of Rwandan public primary school teaching staff regarding the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	8, 9, 10, 20, 21
RQ4. What practices or behaviours are Rwandan public primary schools using to enable the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	6, 7, 11, 12, 13, 14, 15, 16, 18, 19

All interviews were undertaken in a mix of English and Kinyarwanda. Initially, I intended to interview school staff in English only, being listed as one of Rwanda's official languages and used as the language of instruction for pupils in Primary 4 and above since 2008 (McLean Hilker, 2011b). However, practice interviews during the initial pilot and subsequent conversations with teachers at the four case study schools revealed that many of them did not yet feel comfortable and confident to express themselves in English. In light of this, and my limited knowledge of Kinyarwanda, I liaised with Laterite to recruit and train a bilingual interpreter to support the interview process.

The use and effect of translators in cross-language social science research is widely debated and contested. Positivist traditions typically frame the interpreter as performing a mechanical and technical function, the neutral conversion of words from one vernacular into another, albeit a process that raises certain challenges to be controlled for and overcome (Berman & Tyyskä, 2011). Temple and Edwards (2002) meanwhile emphasise a more interpretivist approach to translation, highlighting the opinions, assumptions and concerns that the interpreter brings to the research, and his or her active role in constructing the resultant knowledge through the selection, omission or embellishment of words and responses.

As noted above, this study adopted a post-positivist paradigm and I therefore sought to strike a balance between these competing approaches. On the one hand, I recognised the visible role of the interpreter to not just navigate the linguistic complexities of the translation, but also to capture the perceived meaning of the responses and shape the generation of the emerging data. On the other, I introduced several measures to ensure the accuracy and quality of the translations. For example, I arranged the interview seating into a triangular configuration to maintain regular eye contact with both respondent and interpreter, and between themselves, and used active listening strategies such as nodding to signify that I was engaging with the conversation, even in Kinyarwanda (Berman & Tyyskä, 2011; Lyons & Roulstone, 2017; Temple & Edwards, 2002). I further organised for a selection of interviews to be checked by a second bilingual translator, details of which are set out in Chapter 6. In any case, all of the respondents spoke at least basic English and this provided them, at least in theory, with a chance to check and correct any inaccurate translations, although none of them seemed to use this opportunity.

The process for recruiting the interpreter also provided some comfort concerning the accuracy of his translations (Squires, 2009). Experienced research staff at Laterite who were themselves native Kinyarwanda and fluent English speakers assessed the interpreter before his appointment. Indeed, the interpreter had already worked in translation for over 4 years with some large international organisations, having grown up and lived in Rwanda for most of his life, aside from brief periods when he studied in North America.

Working with an interpreter offered a couple of key benefits. First, participants were free to respond in whichever language they preferred, in all but one case being Kinyarwanda. They could therefore focus on articulating their thoughts and conveying their opinions clearly without the added complexity of answering in English (Mason, 2002). Second, this approach helped to avoid any risk of speaking to elites only, and enabled respondents from all social strata to participate in the research (McLean Hilker, 2011b).

Despite their challenges, conducting the interviews in a mix of languages arguably allowed for greater authenticity in the data collection, both regarding the participants able to respond and the words they could use to frame their answers. Subject to permissions and ethical considerations, the conversations were audio-recorded and fully transcribed afterwards. Section 3.7 below outlines the main ethical issues involved in this, while Chapter 6 describes in detail how the interviews were processed, reviewed and analysed.

Interviews can nevertheless be time-consuming and resource-intensive, especially where verbatim transcription is required. Further, they can be vulnerable to researcher positionality and bias above and beyond translation, as they necessarily comprise an interactive exercise (Mason, 2002; Pope & Denicolo, 1986). There is the additional risk that participants provide aspirational rather than real answers, creating a mismatch between what they say and what they do. This may be particularly pertinent to understanding teachers' *behaviours*, since comportment, demeanour and even habits may be unconscious and go unreported in interviews. For these reasons and to increase internal validity, I supplemented the data from interviews by observing a selection of lessons in the case schools.

3.6.2 Lesson Observations

Observation offers a systematic and complementary approach for examining phenomena, including people, behaviours and events, in their own environment. As Cohen et al. (2015) note, "[t]he distinctive feature of observation as a research process is that it offers an investigator the opportunity to gather 'live' data from naturally occurring social situations" (p. 456). This can enable the collection of more authentic and valid data than would be achieved using inferential or mediated approaches only.

In this study, the observations sought to address RQ4 and serve two main purposes. First, they permitted the exploration of practices and activities that take place in real Rwandan classroom settings, to identify potential links between what teachers do and how children learn generally, and develop cognitive flexibility specifically. Second, the observations helped to draw connections between teaching staff's reported and actual behaviours, and thereby triangulate their interview responses. This was particularly important in a context where teachers are conversant with the mantras of 'child-centred learning' and 'competence-based approaches' but often less clear about what they mean in practice.

As indicated above, three teachers in each school were observed over two initial sessions. Further observations were conducted with a couple of teachers to try to achieve theoretical saturation (Cohen et al., 2015). The observations used a semi-structured schedule to generate 'thick' and narrative descriptions, which enabled greater complexity, richness and completeness in the research (Robson, 2011). This open and more exploratory approach also reflected the seeming lack of pre-existing instruments[18] for identifying practices that support cognitive flexibility generally, let alone in low-income contexts (Meltzer & Bagnato, 2010). The schedule therefore drew on the largely qualitative observation tools developed by the Teaching Effectively All Children (TEACh) programme[19], adapted to capture a wider range of classroom activities, some of which could nurture pupils' cognitive flexibility. Appendix 5 provides an example of a completed observation schedule.

[18] There are numerous highly structured and established tools for evaluating classrooms and lesson quality, not least the *Classroom Assessment Scoring System*, *Early Childhood Environment Rating Scale* and *Teacher Observation in Preschool* protocols. While some of these draw on pedagogies for improving executive function, such as *Tools of the Mind*, none seem to explicitly identify practices that could support cognitive flexibility specifically.

[19] Details of TEACh can be found at https://www.educ.cam.ac.uk/centres/real/researchthemes/qualityteachers/effectiveteaching/.

Within each observation, the main focus was on capturing and recording teacher practices and behaviours, including pedagogical styles, the use of learning aids or formative assessment, and any other activities that *could* nurture pupils' cognitive flexibility. The latter activities encompassed pupils looking at issues from multiple perspectives, switching between languages or applying learning to solve a real-life problem. The focus on *teacher* practices was in accordance with the proximal processes highlighted in the theoretical framework, as well as wider literature on the importance of teaching quality for children's learning outcomes (Singh & Sarkar, 2012; Tikly, 2011). There was nevertheless an opportunity to summarise pupil activities periodically during the observation period to ensure that key actions or incidents were not ignored or overlooked (Patrick et al., 1997).

Like other research methods, however, observations suffer from numerous methodological weaknesses. The first is that observations can be vulnerable to the researcher's bias in interpretation, whether through faulty memory or selective focus on particular events (Cohen et al., 2015). To address this, and subject to the teachers' consent, most of the lessons observed were also video-recorded. This approach allowed repeated viewings, helped to stimulate teachers' recall in subsequent interviews, and permitted more nuanced analysis of how teachers engaged with groups and individual pupils (Mukama, 2010).

There is also the Hawthorne effect and "the extent to which an observer affects the situation under observation, a phenomenon referred to as *reactivity*" (Robson, 2011, pp. 316–317, original italics). Indeed, practices during the first pilot highlighted not just the challenge of reactivity, but also the delicate balance to be struck between observer invisibility and observation depth. As a complete and 'invisible' observer, I sat at the back of the classrooms and took notes by hand to avoid keyboard noises and thereby reduce any distraction to both teachers and pupils alike (Taber, 2013). However, this gave me limited vision of the children's activities when they broke into group exercises. In reality, there was no ideal solution and I therefore used the same approach in the main fieldwork and remained as a complete observer to minimise reactivity and thereby access as authentic classroom behaviour as possible (Patrick et al., 1997).

Finally, observations can only capture external behaviours and therefore offer little insight into children's internal mental processes. For this reason, the case study also involved assessing primary school pupils on a range of cognitive competencies.

3.6.3 Pupil Assessments

During a 4-week period, the fieldwork team conducted numerous games and surveys with Primary 1 and 4 pupils to examine their cognitive flexibility, related competencies and other child-based characteristics to thereby address RQ1 and RQ2. Figure 3.8 below maps out the overarching conceptual framework which draws on the literature described in Chapter 2 and guided the approach to pupil assessments and surveys. Table 3.7 meanwhile shows the instruments trialled during the first pilot and those used in the main fieldwork, discussed in greater depth below.

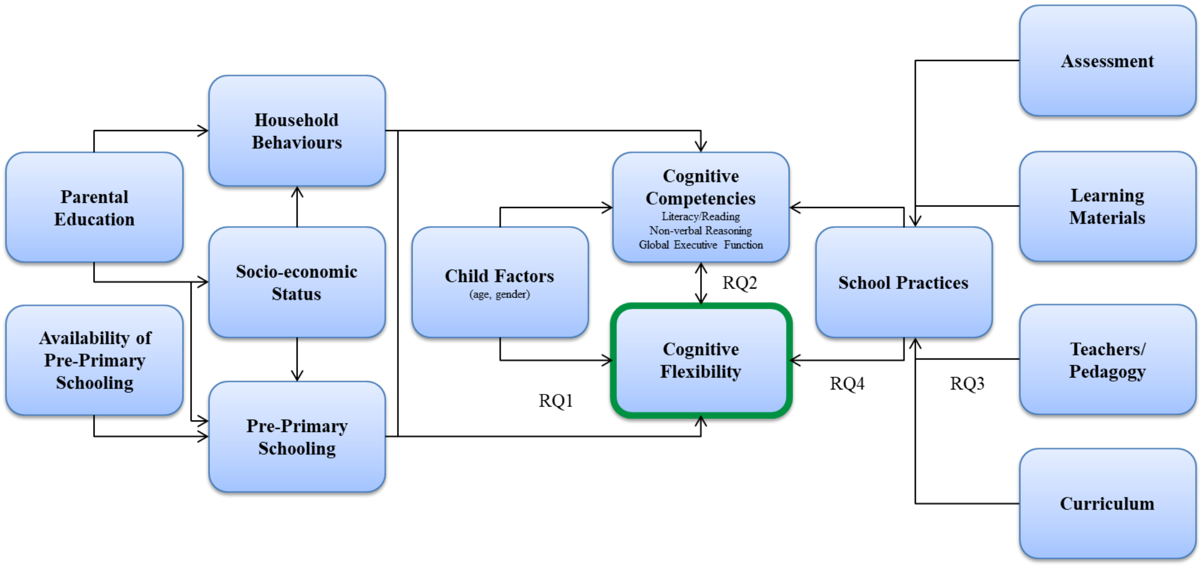


Figure 3.8 - Conceptual Framework for Cognitive Flexibility Development

All children undertook the same tests "using the assessments as criterion-referenced tests, rather than norm-referenced ones" (Malmberg et al., 2011, p. 127). The battery of measures had been designed to ascertain pupils' levels of cognitive flexibility and other competencies, but children did not need to be literate or numerate to participate, with the exception of the literacy assessment[20]. The enumerators administered the tests to pupils individually, in a fixed order and in their mother tongue, presumed to be Kinyarwanda, although this was checked at the start of each assessment (Espy et al., 2006; Podjarny et al., 2017; Traverso et al., 2015). The pupils were also surveyed at the end of the session to capture some indicators of their household context, behaviours and prior education.

[20] The Flexible Item Selection Task also required pupils to count up to three, or at least distinguish three items from one or two.

Table 3.7 - Cognitive Competency Measures

Competency	Measure	Reference(s)	First Pilot	Main Fieldwork
Cognitive Flexibility	Multidimensional Card Selection Task	Podjarny et al. (2017)	✓	-
	Dimension Change Card Sort	Zelazo (2006)	✓	✓
	Wisconsin Card Sorting Test	Grant and Berg (1948)	✓	-
	Flexible Item Selection Task	Jacques and Zelazo (2001); Dick (2014)	-	✓
Non-verbal Reasoning	Object-based Pattern Reasoning Assessment	Zuilkowski et al. (2016)	✓	✓
Global Executive Function	Tower of Hanoi	Borys, Spitz and Dorans (1982)	✓	✓
Literacy/Reading	Early Grade Reading Assessment (partial)	RTI International (2011)	-	✓
	Fluency Assessment in Rwandan Schools (partial)	Education Development Center (2017)	-	✓

Finding quiet spaces in the different schools to conduct the assessments proved a considerable and ongoing logistical challenge. Given the pressing resource constraints, none of the schools had unused or spare classrooms and so the field staff tested pupils in a mixture of storage rooms, computer laboratories and nurseries[21], often moving locations between the morning and afternoon sessions. In one of the schools, there was no indoor space available and so assessments took place under umbrellas in an alleyway behind the staff room.

Throughout the assessments, the field team and I sought to reduce interruptions and background noise wherever possible. Although, as discussed in section 2.2.3, cognitive flexibility likely draws on children's inhibitory control, I wanted to keep distractions to a minimum and thereby avoid 'task impurity'. Where this was not feasible, enumerators were instructed to wait until the disruption had passed before starting the next task, or to provide comments on the tablet where an activity had already begun.

There is nevertheless the argument that these distractions and diversions actually *improved* the ecological validity of the data (Cohen et al., 2015). Ecological validity, a component of external validity, concerns the extent to which research methods reflect the reality of an environment and can be generalised to another context (Brock-Utne, 1996). With reference to executive function, McCoy (2019) suggests that "an ecologically valid measure is one whose scores represent the…skills necessary to succeed in the classroom (or other environment of

[21] Children in the kindergarten classes only attended in the morning, enabling the use of their classrooms in the afternoon.

interest), including the ability to pay attention, wait for one's turn, and avoid calling out answers" (p. 67). In the case of Rwandan pupils, a silent and controlled assessment environment would therefore likely be unfamiliar and foreign, and so some degree of noise and distraction was probably more representative of their academic learning and wider life experiences.

Beyond physical practicalities, measuring children's cognitive competencies across ages and contexts posed various methodological challenges. Von Suchodoletz, Uka and Larsen (2015) query the stability of functions such as self-regulation and suggest that they can vary across different microsystems even within the same community. Zuilkowski et al. (2016) further highlight the presentational aspects of testing, for example, the need to work left-to-right and the dimension of the relevant measure. They argue that:

> [a]lthough most Western children are exposed to extensive two-dimensional materials during early childhood, such as picture books and photographs, most rural African children are not…assessments using two-dimensional stimuli, such as line drawings or patterns, may be inappropriate for capturing cognitive development in settings where such formats are unfamiliar to young children (p. 341).

The performance indices used to capture assessment data can also dictate their use and application. For example, much cognitive development literature focuses on whether a child passes or fails a particular task and at what age, which can reduce the sensitivity of relevant measures and limit their suitability to evaluate performance across a wider age range (Espy et al., 2006; Pritchard & Woodward, 2011). Regarding assessments for cognitive flexibility specifically, Podjarny et al. (2017) argue that much research to date has suffered from a narrow emphasis on children's perseveration, their inability to shift between rules or dimensions. Instead, multiple indices for switch costs and dependent variables, such as accuracy *and* response time, should ideally be used in measuring executive functions to thereby enable a more fine-grained analysis of their development (Best et al., 2011; Cragg & Chevalier, 2012).

Cutting across these issues is the need for measures to be valid and reliable. Regarding the former, Barnett, Ayers and Francis (2015) emphasise the importance of instruments being valid and developmentally appropriate, measuring what they purport to measure and thereby offering meaningful inferences in the specific setting. As noted above, there had been relatively few assessments for executive function validated in an African context before the fieldwork was undertaken (Bellaj et al., 2016; Wanless et al., 2011).

Beyond construct and cross-cultural validity, there are further difficulties with measuring cognitive processes reliably, and yielding replicable results over time and groups of respondents (Cohen et al., 2015). Historically, calculations to determine Cronbach's Alpha have been used to examine reliability and to quantify how well and consistently assessment items correlate with one another (Barnett et al., 2015; RTI International, 2016). However, measures for executive function tend to offer fairly low test-retest and internal reliability, particularly when assessing more complex functions (Blair, 2016; Miyake et al., 2000). This could be explained by the poor definition or operationalisation of the relevant construct, the malleability of executive functions especially in early childhood, or the fact that executive control appears most engaged for *novel* tasks, which can only be new once (Rabbitt, 1997).

To address these issues and as indicated above, several measures for cognitive flexibility and other competencies were trialled with pupils during the first pilot, administered again in the second pilot and then used in the main fieldwork. These assessments are described in detail below and set out in Appendix 6. However, two measures from the initial pilot, the Multidimensional Card Selection Task (MCST) and the Wisconsin Card Sorting Test (WCST) were found to be unsuitable for inclusion in the main battery (Grant & Berg, 1948; Jacques & Zelazo, 2001; Podjarny et al., 2017; Zelazo et al., 2004). A review of these assessments, reasons for their exclusion from the main fieldwork and summaries of the pilot results are included in Appendix 1.

Dimension Change Card Sort

The Dimension Change Card Sort (DCCS) developed by Frye, Zelazo and Palfai (1995) and refined by Zelazo (2006) is a widely used tool for assessing cognitive flexibility, and particularly among young children. This deductive measure reduces demands on individual participants by specifying the sorting rules in advance and uses images of familiar objects such as rabbits and boats rather than geometric shapes. In each case, children are required to sort a pack of cards against two target cards, traditionally a blue rabbit and a red boat. During the first round, children sort by colour before switching to place cards by shape in the second round. More advanced rounds involve the use of borders or stars to indicate whether the card should be sorted by shape or colour.

Use of the DCCS followed the Zelazo (2006) protocol closely, save that the blue rabbit and red boat were replaced with a green goat and yellow motorcycle to increase cultural appropriateness and ensure the children's familiarity with the items. The enumerators administered the task and recorded learners' responses using pre-programmed tablets loaded with the SurveyCTO coding. In the third round, inclusion of a black border required that pupils sort the card by colour while its absence guided them to sort by shape. Use of the border meant that children had to shift back and forth between the rules continuously which was deemed to capture their cognitive flexibility more completely (Cragg & Chevalier, 2012). The border also required that pupils attended to two card dimensions simultaneously, the presence or absence of a border *and* the colour or shape, arguably accessing their concurrent as well as their switching cognitive flexibility.

During the fourth round, pupils repeated the border task but under timed conditions. They were provided with a guide card which outlined the rules in a pictorial format to minimise demands on their working memory to remember the relevant rules. In each case, the number of correct sorts was recorded as the main dependent variable. Figure 3.9 shows the task being used in one of the Rwandan schools.

Figure 3.9 - DCCS

Flexible Item Selection Task

In addition to the DCCS and to triangulate results, pupils' cognitive flexibility was further assessed in the main fieldwork using the Flexible Item Selection Task (FIST) developed by Jacques and Zelazo (2001) for use with pre-school children. The task requires that pupils consider the stimulus pictures on one dimension, and then shift to consider them from two or more different perspectives. An advanced version of the test is described by Dick (2014) and expands the number of matches to examine cognitive flexibility over a wider range of ages.

Like the WCST, the FIST is an inductive measure of cognitive flexibility and requires that participants infer the relevant dimensions for themselves (Jacques & Zelazo, 2001). In each case, they are presented with three or four pictures and asked to identify "'two things that go together in one way' and then to point to 'two things that go together in another way'" (Podjarny et al., 2017, p. 207). In the three-picture trials, there is a 'pivot' item which matches the other images on different dimensions, which could be shape, size, colour or number, while the non-pivot items match on no aspects (Cragg & Chevalier, 2012). In the advanced version, up to six matches are possible using images similar to those depicted in Figure 3.10 below.

Analysis by Dick (2014) revealed significant relations both between all FIST measures with each other and on WCST scores. He therefore determined that they both assess the same underlying construct and that the FIST provides a valid measure of individuals' ability to shift their cognitive set. The test however enables participants to build up their understanding through practice criterial trials and thereby offers an advantage over use of the WCST.

Unlike the DCCS, the FIST was not trialled during the initial pilot, in which case the second pilot offered an important opportunity to test the measure in the Rwandan context. Administration followed the Dick (2014) protocol closely and drew on the same stimuli, save that the images were replaced to be more familiar to Rwandan children. Specifically, rabbits, boats and flowers were replaced with chickens, cups and shoes. Also, rather than using several picture cards for each trial, the images were contained in multiple boxes on one larger card to simplify enumeration and ensure that the measure was consistently administered. Appendix 1 describes the experience of using the FIST during the second pilot while Appendix 6 sets out the task instructions.

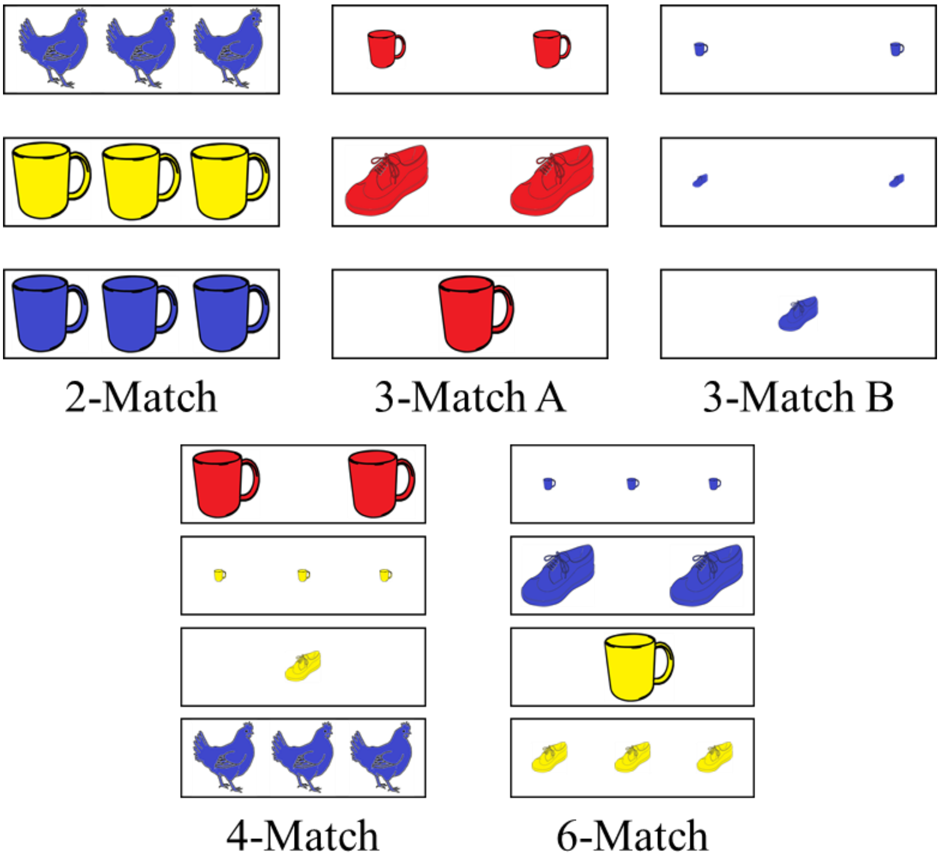


Figure 3.10 - Examples of Five FIST Manipulations
(Adapted from Dick (2014), p. 17, Figure 1)

Beyond measuring pupils' cognitive flexibility, the research focus and in particular RQ2 considered its interaction with the development of other cognitive competencies. For the purposes of the case study, these are prescribed as comprising non-verbal reasoning, global executive function and literacy.

Non-verbal Reasoning

Non-verbal reasoning skills concern an individual's ability to hold multiple pieces of information in mind and see how they relate, or to identify and therefore predict patterns and sequences from a set of visual stimuli (Diamond, 2014; Zuilkowski et al., 2016). Such skills require neither numeracy nor language capabilities and so are widely considered to be indicators of general and fluid intelligence. In terms of measuring cognitive flexibility, non-verbal reasoning skills provide the basis for participants to abstract salient information and identify common dimensions in inductive assessments such as the FIST.

Raven's Progressive Matrices are an established and widely used tool for examining non-verbal reasoning. However, as noted above, two-dimensional measures used to assess such competencies among children in high-income countries may introduce instrument bias and prove unsuitable for use in lower-income contexts. To investigate this issue, Zuilkowski et al. (2016) compared two-dimensional test scores for 2,711 Zambian 6-year-olds against their performance on a new, three-dimensional measure for non-verbal reasoning, the Object-based Pattern Reasoning Assessment (OPRA).

The OPRA builds on an earlier version[22] and uses local objects such as stones, beans, beads and bottle tops to create patterns on a paper grid. One of the spaces is left empty and the children must decide which item completes the sequence. Findings from the Zambian study suggest that dimensionality does indeed affect children's pattern recognition in non-verbal reasoning assessments. While the OPRA scores were largely normally distributed, results from the two-dimensional measure were highly skewed and an ordinary least squares regression revealed significant bias in favour of children exposed to books and other printed materials.

In light of this research, an adapted version of the OPRA was included in both Rwandan pilots and the main fieldwork. Whereas the original OPRA contained basic AAAAAA, ABABAB and ABCABC patterns, the pilots introduced trials using more complex AABBCC and ABCCBA sequences, to reflect the older age of its participants. Figure 3.11 shows the task in use while Appendix 1 contains analyses of the scores from the first pilot.

[22] The Tactile Pattern Reasoning scale – see Fink, Matafwali, Moucheraud and Zuilkowski (2012).

Figure 3.11 - OPRA

Global Executive Function

As discussed in the preceding chapter, cognitive flexibility draws on working memory and inhibitory control, and comprises an inseparable component of the overall executive control system. The Rwandan pilots and main fieldwork therefore included the Tower of Hanoi task to understand cognitive flexibility growth in light of children's more global executive function development.

The precise construct assessed by the Tower of Hanoi remains hotly contested. On the one hand, analysis suggests that when used with children it loads most highly onto a 'planning' factor related to the organisation and execution of deliberate tasks to achieve a specific goal (Welsh et al., 1990, 1991). On the other hand, Miyake et al. (2000) argue that its construct validity is poorly established, while Bull, Espy and Senn (2004) observe that "children do not appear overtly to pre-plan their moves before implementation, as they do not pause before moving the disks…or do not appear to be implementing systematic move sequences" (p. 751). There are further debates around the equivalence of the Tower of Hanoi with a similar 'planning' task, the Tower of London.

Notwithstanding these discussions, the Tower of Hanoi offered two advantages for the present research. First, the study by Bull et al. (2004) which compared children's performance across the Towers of London and Hanoi tasks found that the latter relates most closely to cognitive flexibility, indeed, performance on the Shape School shifting assessment best predicted Tower of Hanoi scores and accounted for 20 per cent of the performance variability. Second, the Tower of Hanoi provides a fairly simple, three-dimensional task with minimal rules that can be undertaken by young children without the need for numeracy or literacy skills (Borys et al., 1982).

In its basic form, the Tower of Hanoi comprises a wooden board containing three pegs and several disks of different sizes (Bull et al., 2004). The aim of the task is to transfer the disks to achieve the desired configuration using the minimum number of moves and complying with the specified rules[23]. In each case, "[t]he minimum number of moves required to achieve solution is 2^n-1, where *n* is the number of disks" (Borys et al., 1982, p. 88, original italics).

Protocols for administering the Tower of Hanoi vary in their approach. Borys et al. (1982) begin with the most difficult trials which gradually get simpler, meanwhile Bull et al. (2004) advocate progressing from easiest to hardest. The main fieldwork followed the latter to start with the simplest exercises and build up towards the timed three- and four-disk trials at the end (Bull et al., 2004; Welsh et al., 1991). Pupils needed to pass simpler rounds to progress to more advanced trials, and were allowed a maximum of 2 minutes per round. The enumerators also advised them when they had broken the rules or used too many moves, and trials were discontinued if children failed to complete two consecutive rounds. Appendix 6 sets out the administration protocol while Appendix 7 contains the final scoring structure.

[23] These are: (i) a larger disk must not be placed on top of a smaller disk; (ii) only one disk may be moved at a time; and (iii) all disks must be on a peg or in the child's hand at any time (Welsh et al., 1990).

Literacy and Reading

Finally, Rwandan pupils' emerging literacy and reading skills were measured as part of the learner assessments. To date, considerable research by Cartwright (2008, 2009, 2012) has examined the relationship between children's reading and cognitive flexibility development. In particular, she highlights the latter's importance for acquiring pre-reading skills, word-reading proficiency and wider comprehension, through the simultaneous processing of multiple cognitive representations. She suggests that "many struggling readers are inflexible, focusing only on words' letters and sounds without paying attention to meaning, which impairs their reading comprehension" (Cartwright, 2012, p. 30).

Meltzer and Bagnato (2010) similarly report that cognitive flexibility can relate to various reading functions. They emphasise its potential role in switching flexibly to achieve letter-sound decoding, access sight-word vocabulary, and link word-level features with the context to draw inferences. Aside from the strength and dynamics of the relationship, however, there is the issue of causal direction. At present, much of the literature emphasises the importance of cognitive flexibility for reading acquisition, but little seems known about whether the reverse could also be true.

Unlike measures for cognitive competencies, numerous instruments for assessing reading have already been validated among Rwandan pupils. These include the Learning Assessment of Rwandan Schools, the Early Grade Reading Assessment (EGRA) and the Oral Reading Fluency Assessment of Rwandan Schools (FARS), each of which examine children's performance at different levels or on different literacy sub-tasks (Moulton, 2016). They also outline some of the particular issues inherent in measuring reading *in Kinyarwanda*, not least the use of longer, multi-syllabic words which are harder for students to decode, and which undermine the direct comparability of words-correct-per-minute speeds (RTI International, 2016).

Pupils' literacy was therefore assessed across a range of functions recognising the multiple sub-tasks involved in reading and the different roles that cognitive flexibility *could* play in supporting them. These sub-tasks are outlined in Table 3.8 below, together with a description of the measure and their respective reliability, where available.

Table 3.8 - Rwandan Literacy Measures, Reliability and Source

Literacy/Reading Measure	Tool	Activity Description	Reliability Score (Cronbach's Alpha)
Letter-Sound Activity	EGRA	Pupil sounds up to 100 letters in Kinyarwanda	0.82
Familiar Word Fluency Activity	EGRA	Pupil reads up to 50 familiar words in Kinyarwanda	0.76
Reading Comprehension Activities A	FARS	Pupil reads a short story (5 sentences) in Kinyarwanda	Not specified
	FARS	Pupil answers 5 basic comprehension questions about the short story	Not specified
Reading Comprehension Activities B	EGRA	Pupil reads a longer story (7 sentences) in Kinyarwanda	0.85
	EGRA	Pupil answers 5 basic comprehension questions about the short story	Not specified

Source: RTI International (2012), Education Development Center, Inc., (2017).

In each case, the measure was designed as a criterion-referenced test and assessed reading in Kinyarwanda only, not English (Moulton, 2016). They were also sequenced so as to represent the accumulation of reading skills and used 'stop' mechanisms to preclude a pupil from moving onto the next stage of the test without demonstrating proficiency on the preceding task. Finally, the reliability scores available were deemed acceptable or good, exceeding 0.70, and therefore appropriate for inclusion in such a low-stakes assessment (RTI International, 2012, 2016).

3.6.4 Pupil Questionnaires

The preceding chapter noted the many bioecological factors that may shape children's psychological development generally, and their cognitive flexibility specifically. Indeed, the theoretical and conceptual frameworks recognise the influences in the home and community microsystems that can affect how they learn and mature. Understanding the complexity of these dynamics and interactions would entail a very different research design, but it is nevertheless important to identify and control for certain factors. In which case, participating pupils were surveyed at the end of their tests to ascertain valuable information about their prior schooling, home life and other background variables.

Surveys conducted through questionnaires provide a useful approach to gather a small amount of quantitative data from a large body of individuals through fixed and standardised questions (Cohen et al., 2015; Robson, 2011). As with the literacy assessments, there were already various pre-existing and validated tools used for measuring households' SES across Rwanda (Friedlander & Goldenberg, 2016). However, while considerable literature emphasises the close relationship between home SES and children's executive functions, there is also evidence that particular family behaviours can mitigate the impact of financial disadvantage (Cartwright, 2012; Clark et al., 2013; Jacob & Parkinson, 2015; Sarsour et al., 2011).

For this reason, pupils were asked about a wider range of home factors and proximal processes than just the conventional measures for Rwandan SES. In each case, the questions reflected literature on the development of children's executive functions. In some instances, they drew on established tools like the FARS and related closely to household poverty or wealth, for example, the availability and use of reading materials in the home, how often the pupils ate protein-rich foods like meat, fish and eggs, and whether they had eaten or drunk anything before coming to school that day (Education Development Center, Inc., 2017; Weatherspoon et al., 2016). In other cases, the questions asked children about the number of languages[24] spoken at home and the emotional environment, using simple pictorial flashcards to capture their more impressionistic responses (Scott, 2002). A full list of variables is set out at Appendix 8 while the pupil survey is included at Appendix 6. Figure 3.12 also shows an updated theoretical framework that highlights the diverse school- and home-based factors that informed the design of the questionnaire. The coloured text indicates how the research methods explored the different processes in children's micro- and mesosystems.

[24] The focus here was on the multiplicity of languages spoken rather than whether they spoke English, French or another language in addition to Kinyarwanda.

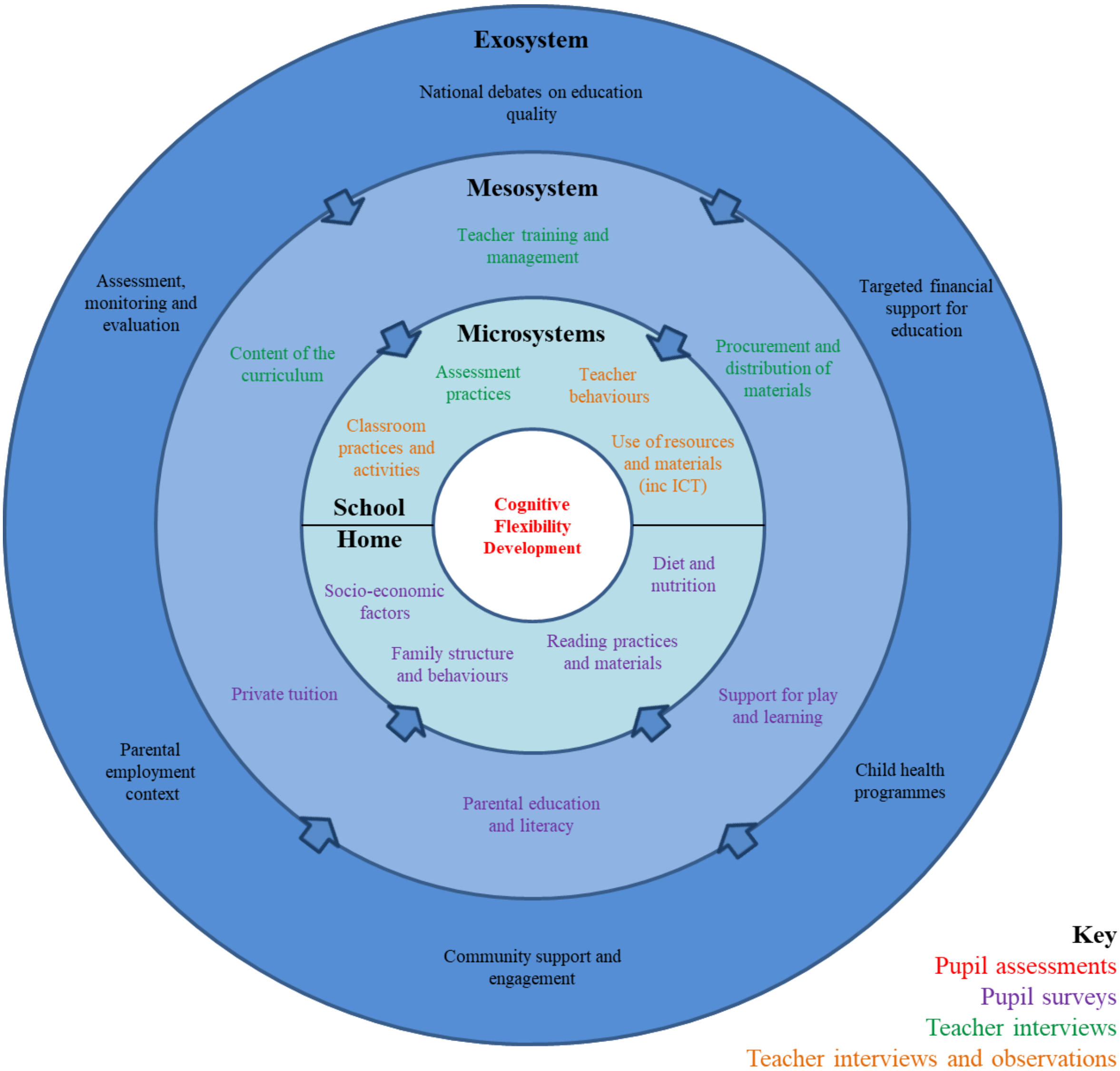


Figure 3.12 - Updated Theoretical Framework

3.7 Ethics and Positionality

Conducting the research described above raised a host of ethical issues, both practical and methodological. Throughout, the study was undertaken in accordance with approvals and ethical clearances from the University of Cambridge and the University of Rwanda (Approval Notice: No 421/CMHS IRB/2017), being set out in Appendix 9. I was further guided by the principles outlined in the British Educational Research Association (BERA) Guidelines (2011, 2018), particularly as they relate to voluntary informed consent, the avoidance of harm and the need for confidentiality and anonymity.

3.7.1 Voluntary Informed Consent

The need for participants' voluntary informed consent is well-established in social science research. Specifically, they must understand the background and purpose of the intended study, and how their data will be processed and used (BERA, 2018; Cohen et al., 2015). In light of such information, the respondents must also voluntarily agree to participate in the research, but may withdraw their consent without reason at any stage of the study.

Securing schools' agreement to take part in the research entailed many weeks of regular meetings and continuous engagement. Following initial contact, the field coordinator and I visited the schools to provide detailed explanations, information sheets and consent forms, in both English and Kinyarwanda. Such documents are included at Appendix 10. In some of the schools, the head teachers also asked me to run through the various assessments with them, while in others they consulted different members of staff to solicit their opinions before making a final decision.

Throughout the process, I sought to strike the right balance of enough detail for informed consent, but without undermining the purpose and validity of the study. In particular, I was concerned that too much information might cause the school principals or teachers to alter their behaviours such that observations and interview responses would no longer be authentic. I was also conscious that some head teachers might have felt pressured to participate by virtue of the district offices' approvals and endorsements of the study. I therefore made specific efforts to repeatedly assure both principals and teachers on numerous occasions that they were absolutely free to take part or decline.

Research involving children raises particular challenges regarding the need for voluntary informed consent. On one hand, young people may be independent and autonomous agents, competent to give their own consent (Cocks, 2006). On the other, smaller children might not fully understand the consequences of their decisions and should be able to rely on gatekeepers, such as parents and teachers, for safeguarding and protection (Homan, 2001). In contexts like Rwanda, the difficulties can be especially pronounced if illiterate parents lack the skills to read and return consent forms.

Given these challenges, I adopted a two-pronged approach for the pupil assessments. First, I asked the head teachers to act as gatekeepers and provide consent in *loco parentis* for the children to take part (Homan, 2001). Second, the pupils were themselves briefed orally in Kinyarwanda at the start of each assessment and asked to assent to their participation. Likewise, before video-recording any lesson observations, the teachers read out a short announcement, also in Kinyarwanda, which invited the children to sit outside the camera's sight lines if preferred.

In addition to the information provided, the use of gifts and incentives can also affect respondents' voluntary informed consent if it affects their "free decision to participate" (BERA, 2018 p. 19). In the current study, pupils were rewarded for their participation with stickers and pencils, while the schools asked to receive the research findings and some teachers requested individual feedback on their classes. Overall, I considered these to be appropriate incentives, commensurate with the nature of the study and unlikely to sway any decisions around participation.

More generally, the frequency with which respondents *at all levels* exercised their rights suggested that the procedures were indeed appropriate to ensure their voluntary informed consent. At least three schools and a teacher refused to take part, another agreed to be observed but not video-recorded, while a third was happy to be video- but not audio-recorded. Among the children, two pupils declined to participate in the assessments and another two moved seats to avoid being recorded in the lesson observation.

3.7.2 Doing No Harm

Beyond voluntary informed consent, BERA (2011, 2018) guidance and ethical standards require that researchers must also refrain from doing harm to their participants. Potential risks of harm arose at three particular points in the fieldwork.

First, during early visits to the schools, one of the head teachers proposed using the girls' room as a quiet space for conducting the pupil assessments, while another suggested combining two class groups to make a room available. Naturally, I appreciated the efforts to accommodate the study but using the girls' room, however brief or intermittent, would have temporarily deprived female students of a private place to change their hygiene products. Similarly, I was reluctant for the school to double class sizes given the likely impact on pupils' learning, and so I politely declined the offers and found alternative locations.

Second, a couple of the schools queried the duration of the pupil assessments. Some teachers argued that they should be capped at 40 minutes, not least because pupils only received 4 hours of formal instruction each day. In addition to missed learning, there was also the concern of minimising child fatigue and ensuring that the assessments avoided creating undue strain or pressure for the pupils (Barnett et al., 2015). Indeed, this issue was a primary consideration during the second pilot and the main reason for reducing the number of FIST rounds. As the enumerators gained experience and confidence, the administration times came down and typically lasted between 35 and 50 minutes[25].

Third, I sought to capture impressionistic responses from the pupils concerning the emotional environment in their household, not least given literature on the opposing effects of stress and wellbeing on children's executive function development (Blair, 2016; Diamond, 2016, 2014). Pupils were therefore shown two pictures of a 'typical' Rwandan family and asked which illustration best represented their home life. One picture showed affectionate guardians while the other depicted angry caregivers castigating the children. This question risked raising ethical concerns if it created discomfort for the pupils or framed them as gatekeepers for their private home environments (Homan, 2001). As such, I advised the enumerators on the particular need for sensitivity, instructing them to record 'no response' and move onto the next question if the children showed *any* signs of unease, distress or anxiety.

3.7.3 Confidentiality and Anonymity

Protecting confidentiality and anonymity were also important considerations throughout the study, not least to avoid any unpredicted or adverse consequences for the participants (Bell, 2003; BERA, 2018). At the point of data collection, interviews were held in private offices or

[25] I intended to capture precise information regarding the actual duration of individual assessments, not least by using tablet functions that recorded the start and end times. However, the enumerators would often scroll to the start of the assessment before the pupil had arrived. Also, as an accountability measure, each assessment finished by capturing the tablet's global positioning coordinates, a process which could take a few seconds or as long as 30 minutes during a lunch break. Children had returned to their classrooms during this time but obviously this lag affected the reliability and value of the duration data.

secluded places to both minimise distractions and ensure respondents' freedom to answer without being overheard.

During most of the interviews, the participants agreed for the conversations to be audio-recorded. Such approaches can sometimes inhibit interviewee responses but the school staff seemed generally willing to comply and, after any initial trepidation, many of them spoke with honesty and frankness, sharing details of their challenging work conditions and the difficulties they faced in supporting their families (Burgess, 1988; Tao, 2013). In any case, the respondents were explicitly free to stop the recorder at any time and the principal at one school paused the recording mid-interview for a couple of minutes before resuming.

Following data collection, I coded and anonymised participants' individual records, transcripts and assessments. Specifically, I expunged their names, details of their institutions and any other distinguishing features that could enable their identification. In most cases, I also shared English transcripts with the interviewees so that they could check their responses and attest to their anonymisation. Regarding storage, datasets and transcripts were backed-up on password-protected hard drives, and treated in accordance with both the United Kingdom Data Protection Act 1998 and the European General Data Protection Regulation (GDPR), which came into force shortly after the fieldwork.

3.7.4 Researcher Positionality

Beyond ethical considerations, the positionality of researchers in post-positivist studies can also shape and affect the relevant findings. Semi-structured interviews in particular comprise social interactions, which cannot be isolated from the specific circumstances or personal contexts (Cohen et al., 2015). Similarly, there is the risk of confirmation bias and I needed to remain reflexive about my own role in the resultant 'creation of knowledge' (DiCicco-Bloom & Crabtree, 2006). Consequently, I was aware throughout the fieldwork that my positionality might have impacted not just the conduct of the research, but also the content of participants' responses.

First, my status as a white man from a high-income country and a world-renowned university could have offered benefits in terms of access and credibility, but also framed me as an inevitable outsider. I was able to address this distance in small ways by using Kinyarwanda greetings and referring to my previous work in the country. I had also built up rapport with teachers over several weeks before conducting any interviews in the schools. Most importantly, however, working with a Rwandan field team from Laterite helped to establish trust, present the research as a collective effort and thereby portray the study as an endeavour worth supporting.

Regarding power dynamics, and particularly in a post-colonial setting, my positionality varied between interactions and I assumed a mixture of ‘upper’ and ‘lower’ positions depending on the immediate research situation (Srivastava, 2006; Tikly & Bond, 2013). With school principals, I typically adopted a ‘lower’ stance, while the engagements with teachers differed depending on their age and experience. By contrast, I assumed an ‘upper’ position when liaising with the children, usually in the context of observing the pupil assessments.

Beyond my own status, the positionality of the field team might also have had a bearing on the fieldwork. During interviews, for example, several participants talked for long periods and without breaks for the interpreter to translate their responses into English. When discussed afterwards, the interpreter explained that it would have been unacceptable and culturally inappropriate for him to interrupt the interviewees who were generally older and therefore senior to him.

In summary, this chapter has mapped out the methodologies and practical techniques used to answer the research questions. Interviews, observations and pupil assessments were conducted to explore practices, behaviours and competencies within four Rwandan primary schools. The next chapter turns to the first research question and examines the measurement of cognitive flexibility and factors associated with its development.

CHAPTER 4 – COGNITIVE FLEXIBILITY MEASUREMENT AND DEVELOPMENT IN RWANDA (RQ1)

The previous chapter described in detail the research methodology and different approaches used to generate empirical data to address the four core questions. This chapter draws on the *quantitative* data in particular and answers the first research question (RQ1), which asks "How can Rwandan pupils' cognitive flexibility be measured during the course of their public primary education and what factors are associated with its development?"

Such inquiry offers several valuable contributions to the existing corpus of related knowledge. Specifically, the research would appear to represent the first study of cognitive flexibility undertaken among learners in Rwanda, either adults or children[26]. This holds particular significance given the dearth of data on executive functions in lower-income countries and a growing debate on why international psychologists have overlooked populations beyond Western, affluent and educated contexts for so long (Schulson, 2020). Indeed, by demonstrating that cognitive flexibility *can* be successfully and meaningfully measured in Rwandan schools, the study purports to provide useful insight and practical guidance for further research to be conducted in other similar settings.

Second, in addition to data on the pupils' cognitive flexibility, the study also captured their responses on a wide range of background and household characteristics. In each case, the survey questions were guided by existing literature on factors that have previously shown positive associations with the development of executive functions generally or cognitive flexibility specifically. Although such responses cannot impute causal relations, such as the effect of parental reading, they highlight statistically significant behaviours and practices that may *predict* cognitive flexibility among Rwandan schoolchildren and thereby offer suggestions for how it could be fostered in the future.

Finally, by measuring learners' cognitive flexibility in both Primary 1 and Primary 4, the research enables a comparison of differences across the grades to assess the potential for

[26] In accordance with the research gap highlighted in Chapter 2, literature searches conducted for cognitive flexibility in Rwanda on major databases in both English and French returned no results, save for a recent study by Blanchette et al. (2019), which examined the relationship between experiences of trauma during the 1994 genocide and survivors' executive functions. This does not, of course, preclude the possible existence of unpublished studies or research undertaken and published in Kinyarwanda only.

growth among children enrolled in Rwandan public education. In conjunction with the qualitative findings from lesson observations described in Chapter 7, and notwithstanding the lack of longitudinal data, this may help to reveal the role that schools can play in shaping pupils' cognitive flexibility.

To achieve these aims, the first section explains the analytical approach taken to answer RQ1 while the second section outlines how the two measures of cognitive flexibility, the Dimension Change Card Sort (DCCS) and the Flexible Item Selection Task (FIST) described in section 3.6.3, were used to capture reliable responses in the Rwandan context. The third section compares data across the two primary cohorts, the fourth section uses bivariate analyses and regressions to model cognitive flexibility development, and a fifth section concludes the chapter with a discussion of the findings and their relevance to other parts of the study.

4.1 Analytical Approach

The literature review in Chapter 2 highlighted a wide range of maturational, environmental and educational factors shown or considered to support the development of children's cognitive flexibility. Such influences were subsequently captured in the conceptual framework in Figure 3.8, which included learners' age, socio-economic status (SES) and their family's access to and use of pre-primary schooling. Figure 4.1 below now provides an updated framework which categorises these potential influences according to the different types of factor.

The interactions between these factors are complex and an individual child's cognitive development will depend on a unique combination of personal characteristics and his or her own particular life and educational experiences (Bronfenbrenner & Morris, 1998, 2006). However, in the context of the current study, the research data present an opportunity to model Rwandan pupils' cognitive flexibility and predict their performance based on certain responses, and the presence or absence of other supporting factors.

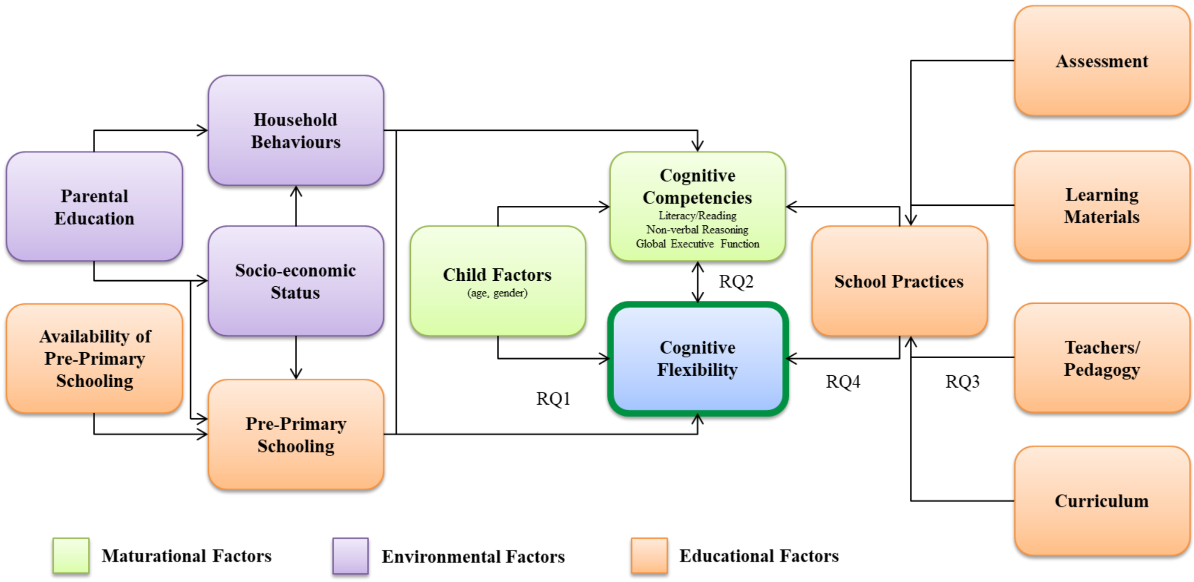


Figure 4.1 - Updated Conceptual Framework

4.1.1 Constructing Cognitive Flexibility

Notwithstanding the intricacies of child development, sections 2.2 and 3.3 revealed that cognitive flexibility can be broadly understood as a function of individual traits and qualities, and the particular processes and practices within a learner's microsystem (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2006). For example, age has a significant, positive and linear effect on children's ability to shift, as evidenced by the study by Holding et al. (2018) with Bangladeshi and Tanzanian learners. Similarly, specific behaviours, such as parents reading with their child, might arguably also strengthen or add to that child's cognitive flexibility. However, this model remains unproven in Rwanda and therefore needs to be empirically tested.

To test the function, I used a linear and additive model of cognitive flexibility development. This approach represented the simplest functional form through which to chart Rwandan pupils' cognitive flexibility and identify the most influential factors. At present, little if any robust evidence exists concerning the predictive effects of *interactions* between different factors on children's cognitive flexibility, and certainly not in lower-income contexts, so no interaction terms were included in the model. Specifically, I sought to understand Rwandan pupils' development by drawing on the factors set out in Figure 4.1 and using the following equation:

$$Y_i = b_0 + b_1X_{1i} + b_2X_{2i} + b_3X_{3i} + u_i$$

where Y represents the cognitive flexibility of pupil i, b_0 is the constant or intercept, X_1 pertains to child-level factors such as their age and gender, X_2 captures significant background or household characteristics, X_3 concerns school- and learning-related considerations, and u reflects the error term which may be attributable to factors including omitted or unobserved variables, or indeed measurement error (Wooldridge, 2002).

As a vector of multiple coefficients, b_3 in particular may represent a combination of several different educational factors showing associations with children's cognitive flexibility development. These could include the location of a pupil's school in either Gasabo or Nyarugenge district, its supposed 'quality' as determined by performance on national examinations, or the use of play-based approaches versus formal instruction in any pre-primary learning experiences. Most importantly, however, b_3 will likely reflect differences in learners' performance attributable to their class grade, Primary 1 or Primary 4. This in turn could represent the combined or discrete effects of children's increased age and life experience, or the cognitive contribution of at least 3 years of additional formal education.

In fact, the equation informed the study to predict learners' cognitive flexibility for both Primary 1 and 4 pupils separately at first, recognising that different factors could show significant associations at different stages of a child's education and development. Specifically, I conducted bivariate analyses to identify factors with statistically significant relationships to one or both measures of cognitive flexibility for learners in Primary 1, and then Primary 4. Next, I ran regressions for each grade using the main and significant factors to ascertain the size and effect of the different beta coefficients. Finally, I combined the data for both cohorts of children, running the regressions again but treating their grade, Primary 1 or Primary 4, as a dichotomous dummy variable to estimate the difference in cognitive flexibility between such pupils conditional on factors shown to be significant in the specific Rwandan context.

Throughout the analyses, I sought to achieve the most parsimonious model, one which prefers simpler explanations over complex accounts, and includes only the main predictors from the conceptual framework and those that offer real explanatory benefit (Field, 2009). However, these parametric approaches also entail certain assumptions about the nature and distribution of the data involved. As such, these assumptions must be unpacked to better understand the

DCCS and FIST scores and the extent to which estimates of pupils' cognitive flexibility can be deemed valid.

4.1.2 Addressing Assumptions

Parametric analyses such as Pearson's correlation coefficient, *t*-tests and linear regressions make particular assumptions about the shape of data distributions for the results to be interpreted at face value. Specifically, such tests assume that the data are additive, linear, independent and free from bias caused by outliers and other extreme values, while parametric models presume that the underlying data are homoscedastic, free from multicollinearity, and normally distributed (Field, 2009). Similarly, the equation described in section 4.1.1 above assumes that the error term, *u*, is random, normally distributed and therefore uncorrelated with the predictor variables (Wooldridge, 2002).

Numerous international studies have already highlighted the additive and linear nature of cognitive flexibility development among children[27]. In particular, a considerable body of literature reports a positive association between pupils' age and their ability to successfully undertake tasks such as the DCCS and the FIST, which suggests that for additional years of life or education there may be an additive and linear change to cognitive flexibility (Bellaj et al., 2016; Best et al., 2011; Dias et al., 2013; Jacques & Zelazo, 2001). Similarly, all pupils in the present study were assessed individually, without opportunities for collaboration or collusion, and therefore learners' observations can be deemed to be reasonably independent of one another.

Homo- and heteroscedasticity describe the stability of the outcome variable variance and can affect the generalisability of the particular model. Specifically, 'homoscedasticity' "means that variance in the residuals must be the same for units regardless of their predicted values" (Mehmetoglu & Jakobsen, 2017, p. 149). Further details concerning the extent to which data in the current research meet the assumption of homoscedasticity are set out below in relation to the particular measures and models.

[27] There is also some literature on the *declining* nature of executive function and cognitive flexibility among the elderly, which would suggest a curved or quadratic trajectory over the course of an individual's lifetime (Jurado & Rosselli, 2007). However, in the context of *children's* development, the evidence points at cognitive flexibility being additive and linear, at least for pupils in the age range of the current study.

Regarding collinearity, children's age, grade and years of prior schooling are closely aligned in many countries but not necessarily equivalent in Rwanda and other lower-income contexts. As outlined in Chapter 2, learners often start school late, drop out or repeat classes which gives rise to wide age ranges within the same grade (Sabates et al., 2010). However, in the present study and as described in Chapter 3, pupils were sampled according to their class *and* their age, and so there is inevitable multicollinearity between these different factors. As such, the regressions were conducted to omit or control for at least one of these variables to ensure that the beta coefficients captured their maximum unique variance[28].

Finally, parametric methods assume that data show a traditional bell-shaped curve, are normally distributed or come from a normal *sampling* distribution. However, under the central limit theorem normality is not always necessary in larger samples with more than 30 respondents (Cohen et al., 2015; Field, 2009). Lumley, Diehr, Emerson and Chen (2002) further demonstrate that analyses such as *t*-tests and linear regressions remain valid for larger samples, notwithstanding the non-normality of their data distribution. In the present study, the total sample of 306 children well surpassed this threshold, indeed, the number of pupils in each grade in each school also exceeded 30, thereby reducing the strict need for data normality.

With the analytical approach and underlying assumptions now outlined, the next section describes the process of transforming the pupil responses into meaningful and reliable measures of cognitive flexibility in the Rwandan context.

4.2 Cognitive Flexibility Assessments

For both assessments, the enumerators recorded the children's reactions to the different stimuli on their pre-programmed android tablets. In the case of the DCCS, this comprised whether the pupil matched a card against the green goat or yellow motorcycle, while for the FIST they recorded the two boxes the child matched and on which dimension. The tablets were also coded in advance to calculate the number of correct responses in each round, which was used to determine the pupil's progression onto more complex trials. In this way, I sought to apply established and validated measures used to assess cognitive flexibility in numerous other contexts with learners in Rwanda for the first time.

[28] Section 8.3 below also describes the particular challenges involved in collecting accurate data on Rwandan children's ages.

4.2.1 DCCS Analysis and Descriptive Statistics

Published studies using the DCCS adopt different approaches for analysing children's performance depending on the purpose, administration and subject population of the research. Early investigations focused on the age at which learners started to show switching abilities, but more recent literature has examined their interaction with other cognitive functions, learning outcomes like literacy and reasoning, and even physical processes such as eye-tracking and neural stimulation (Chevalier et al., 2010; Engel de Abreu et al., 2014; Frye et al., 1995; Tarullo et al., 2017). Similarly, initial versions of the task administered with tangible cards and basic switch rounds have evolved to include more advanced border trials and computerised formats that capture reaction times for every individual match (Dauvier et al., 2012; Zelazo, 2006).

Regarding subject population, the DCCS continues to be commonly used to assess young children, typically between the ages of 3 and 7 (Cook et al., 2019; Podjarny et al., 2017; Society for Research on Child Development, 2014; von Suchodoletz et al., 2015). The simplicity of the task involving shapes and colours makes it suitable for use among pre-literate and – numerate learners, while more complex measures exist to assess switching among older children, adolescents and even adults[29]. According to Western literature, the early age range also represents a critical period in children's cognitive flexibility development. Seminal studies among North American learners suggest that 3-year-olds perseverate on the same initial dimension but by the age of 5, most children can switch successfully when instructed to do so (Frye et al., 1995; Zelazo, 2006).

Each of these factors has influenced how data from the DCCS have been used to measure learners' cognitive flexibility in different studies. In many, such as Carlson (2005), the narrow age focus led to children being categorised simply as either 'switchers' or 'non-switchers' and the use of binary logistic regressions to predict a learner's pass or failure. By contrast, data from computerised versions of the DCCS have enabled rich analyses of the multiple strategies participants use to reconcile the competing demands of speed and accuracy (Dauvier et al., 2012).

[29] Examples include the Wisconsin Card Selection Task, mentioned in Chapter 3, and the Trail-Making Test (Grant & Berg, 1948; Sarsour et al., 2011).

In the present research, I sought to move away from the more simplistic framing of the DCCS that gives rise to a dichotomous switching outcome. Arguably, this approach overlooks the possible changes and gains in cognitive flexibility that may take place even after a child has mastered a basic level of switching. Indeed, these potential differences were important as the first study of learners' cognitive flexibility in Rwanda, working with older children and comparing performance across pupils in both Primary 1 and Primary 4.

Specifically, I adopted two approaches to generate overall accuracy scores for learners' performance on the DCCS. The first approach created an ordinal, non-parametric variable based on the highest round in which participants were able to achieve a minimum number of correct matches (Chevalier & Blaye, 2009; Frye et al., 1995; Hongwanishkul et al., 2005). In particular, pupils needed to achieve at least five out of six sorts correct to pass the pre- and post-switch rounds, and a minimum of nine out of 12 matches during the border trials. Children who failed the pre-switch phase scored 0, while those that successfully completed the pre-switch round but failed the post-switch trials scored 1. Pupils who achieved the switch but then failed both border rounds would score 2, and so on. Table 4.1 below shows a breakdown of the ordinal DCCS scores.

Table 4.1 - Breakdown of Ordinal DCCS Scores

Score	Frequency
0	13
1	116
2	148
3	19
4	10
Total	**306**

Source: Primary data, 2018. Notes: The ordinal score indicates the highest DCCS round that a pupil was able to successfully complete. For example, a child scoring 1 passed the pre-switch round but not the post-switch trial.

The second approach meanwhile drew on the DCCS raw scores and aggregated the total number of correct sorts across the different rounds of the task to create a continuous ratio variable (Zelazo et al., 2013). Following recent studies by Podjarny et al. (2017) and Cook et al. (2019), only post-switch sorts were included on the basis that pre-switch matches simply required a child to sort cards by colour with no apparent need for cognitive flexibility. I further generated a proportional score of correct responses across the task, such approach being used for other measures of cognitive flexibility like the FIST, as discussed in detail below. Details of the Stata coding for these and other analyses are available upon request and the descriptive statistics for both ordinal and ratio variables for the DCCS are set out in Table 4.2 below.

Table 4.2 - Descriptive Statistics for the Ordinal and Ratio DCCS Scores

Variable	Mean	Standard Deviation	Value Range	95% Confidence Interval		*Z*-Score Range
Ordinal	1.66	0.79	0-4	1.57	1.75	-2.09-2.94
Ratio (proportion)	.39	.31	0-1	.35	.42	-1.26-2.01

Source: Primary data, 2018. Notes: The ordinal score indicates the highest DCCS round that a pupil was able to successfully complete. For example, a child scoring 1 passed the pre-switch round but not the post-switch trial. The ratio (proportion) score shows a child's proportion of correct post-switch matches across the whole task.

Of particular note, the standard deviation for the ratio variable is relatively large compared to the mean, which is not uncommon for studies using the DCCS or otherwise measuring cognitive flexibility (Cook et al., 2019; Sarsour et al., 2011; Tarullo et al., 2017). As a result, analysis of the standardised *z*-scores revealed that there were no extreme values lying more than three standard deviations above or below the mean (Field, 2009). The charts in Figures 4.2 and 4.3 nevertheless offer more valuable insight on the *distribution* of the data. Specifically, Figure 4.2 shows a high proportion of children successfully completing the pre-switch colour round (and thereby scoring 1), as well as achieving the initial post-switch sort by shape (and therefore scoring 2). By contrast, far fewer pupils were able to perform the advanced mixed sort rounds (scoring 3 and 4) and a small number of children failed to complete even the first round of colour matches (scoring 0).

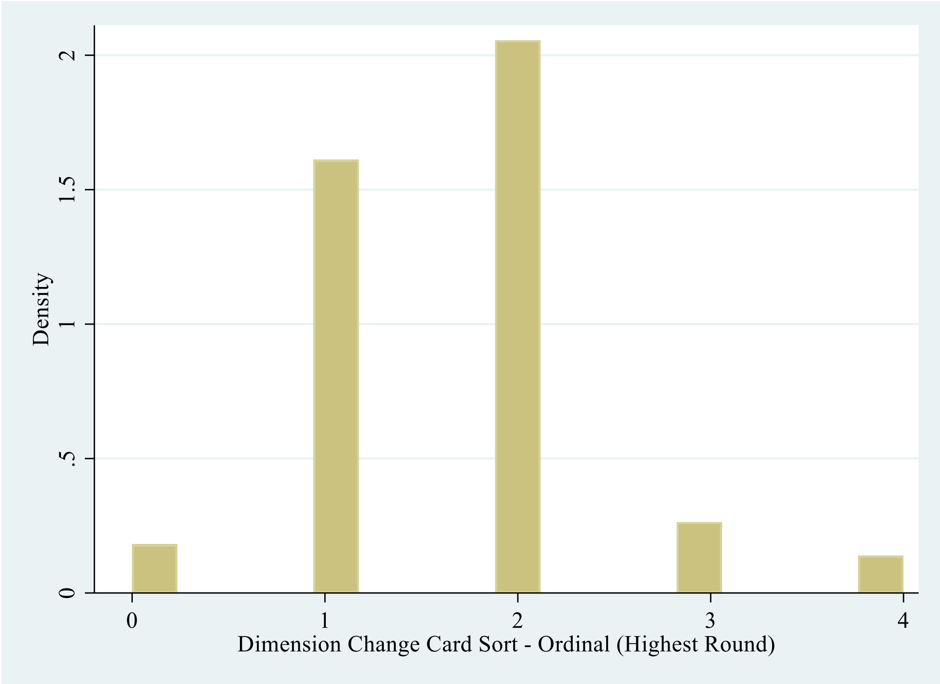


Figure 4.2 - Distribution of Ordinal DCCS Scores

Source: Primary data, 2018. Notes: The ordinal score indicates the highest DCCS round that a pupil was able to successfully complete. For example, a child scoring 1 passed the pre-switch round but not the post-switch trial.

Figure 4.3 meanwhile depicts the ratio variable, showing a bimodal distribution and explaining the large standard deviation relative to the mean. On the left side, the tallest bar combines pupils scoring 0 and 1 on the ordinal variable and represents a high proportion of children unable to achieve any correct post-switch sorts. This is somewhat surprising given the age of the pupils and international literature on when children should be able to achieve at least a basic switch, but a detailed comparison of Rwandan performance against scores from other contexts is beyond the scope of this study (Frye et al., 1995; Zelazo, 2006). On the right side of Figure 4.3, the second clustering of bars shows pupils that could successfully match at least some of the cards and typically achieved at least half of the correct sorts. Noticeably, there are no scores between the two groups, but there is some range in ability among the children that could perform at least the basic matches.

Overall, the ordinal and ratio variables represent alternative transformations of the same pupils' data from the DCCS. The distribution of ordinal scores in Figure 4.2 displays a more typical bell-curve than the ratio variable, but the latter arguably better depicts the reality of children's performance, specifically the bimodal split between learners that could and could not achieve a basic level of switching. Notwithstanding their lack of normal distribution, the ratio scores offer greater nuance for examining pupils' cognitive flexibility using parametric approaches and therefore comprise the main focus in subsequent analyses.

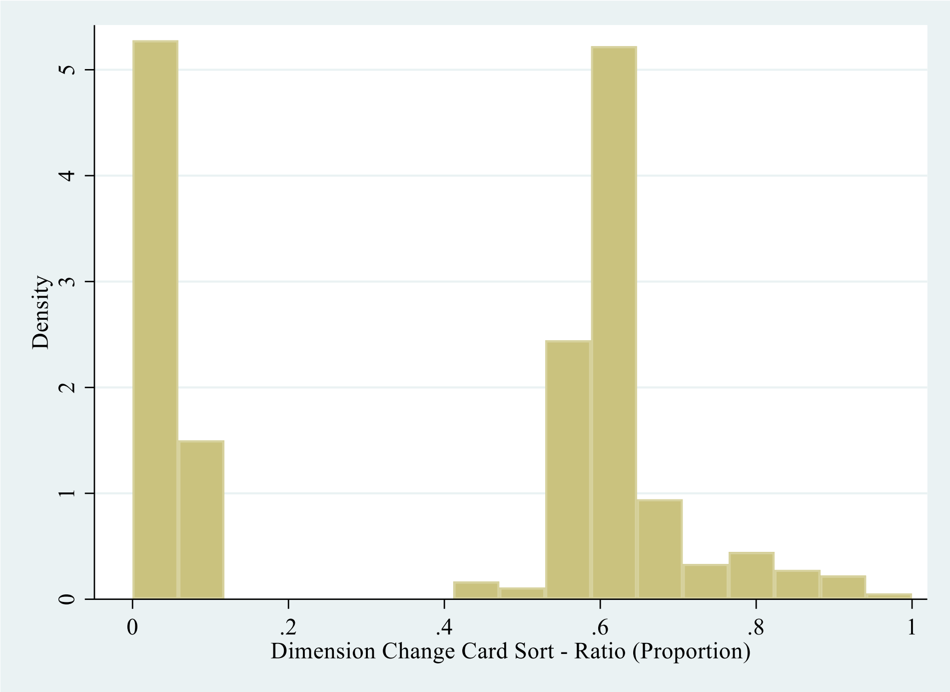


Figure 4.3 - Distribution of Ratio DCCS Scores

Source: Primary data, 2018. Notes: The ratio (proportion) score shows a child's proportion of correct post-switch matches across the whole DCCS task.

4.2.2 DCCS Reliability

As noted in the methodology chapter, reliability presents an important consideration for understanding findings in both case studies and quantitative research (Yin, 2009). Recent studies using the DCCS rarely report on its reliability, however, perhaps because the task is so well established and widely used. Nevertheless, several papers specify Cronbach's alpha for the DCCS, such value indicating the inter-item internal consistency of a measure by calculating "the correlation of each item with the sum of all other relevant items" (Cohen et al., 2015, p. 201). For example, von Suchodoletz et al. (2015) report an alpha of .76 when using the DCCS with 4-5-year-olds in Albania, Engel de Abreu et al. (2014) indicate .87 reliability for a comparable sorting task used in Brazil, and Beck, Schaefer, Pang and Carlson (2011) report test-retest reliability and intra-class correlations of .90 to .94.

Table 4.3 sets out the alpha coefficients for each round of the DCCS in the current study, as well as the overall reliability across all rounds of the measure. Reliability in the final round was somewhat low, perhaps because the pupils were sorting the cards on mixed dimensions and under timed conditions. However, the alphas for the other rounds and the overall alpha for the measure exceed .80, and therefore suggest that the DCCS offers a high degree of reliability in the Rwandan context (Cohen et al., 2015).

Table 4.3 - DCCS Reliability

Round	Cronbach's Alpha	Items
Pre-switch	.81	6
Post-switch	.96	6
Box trial	.81	12
Timed box trial	.68	12
Overall	**.81**	**36**

Source: Primary data, 2018. Notes: The table sets out the alpha coefficients for each round of the DCCS and for the overall measure. The number of items in each round is also specified.

4.2.3 FIST Analysis and Descriptive Statistics

Compared to the DCCS, data from the FIST present fewer processing options. Some studies disaggregate responses by round according to the maximum number of possible matches, while others calculate the dependent variable for the FIST as the proportion or percentage of correct matches across the task (Blair & Razza, 2007; Dick, 2014; Jacques & Zelazo, 2001). I took the latter approach, specifically generating a proportional score of Rwandan pupils' correct responses from the 2-match and 4-match rounds of the FIST.

Like Jacques and Zelazo (2001), I excluded the children's responses from the demonstration and criterial trials of the assessment. Such data were omitted on the basis that these practice rounds only required the children to understand the task, they received feedback on any mistakes and the trials could be completed using basic perceptual-matching strategies, without the express need for abstraction or shifting. A total of 52 pupils across the two cohorts, 45 in Primary 1 and seven from Primary 4, failed the criterial trials and did not undertake the main FIST tasks. In each case, they were recorded as scoring zero, since the omission of such data would overstate the performance of Rwandan learners by focusing on the higher performers only.

Several empirical studies further highlight the importance of distinguishing the different mental processes taking place at various stages of the FIST, not least as an *inductive* measure of cognitive flexibility (Clark et al., 2010; Wong et al., 2008). In particular, Jacques and Zelazo (2001) suggest that the first match in each trial gauges children's abstraction skills, their ability to discern a common dimension across stimuli, and only subsequent matches draw on their ability to shift between dimensions. For this reason, I created further variables based on pupils' abstraction and shifting scores, the latter being of particular relevance for investigating children's cognitive flexibility. Table 4.4 shows the key descriptive statistics for the three separate but related variables.

Table 4.4 - Descriptive Statistics for FIST Dependent Variables

Variable	Mean	Standard Deviation	Possible Range	Actual Range	95% Confidence Interval		Z-Score Range
Total proportion correct	.31	.26	0-1	0-.94	.28	.34	-1.20-2.42
Proportion abstraction	.49	.35	0-1	0-1	.45	.53	-1.42-1.47
Proportion shifting	.23	.24	0-1	0-.92	.20	.25	-0.94-2.89

Source: Primary data, 2018. Notes: The total proportion correct variable indicates the proportion of correct matches from the maximum number of responses across the task. Proportion abstraction indicates the proportion of *first* matches correct across the task, being used to ascertain pupils' abstraction abilities, while proportion shifting denotes the proportion of correct *subsequent* matches (in the case of 2-match, the second match, in the case of 4-match, the second, third and fourth matches).

As with the DCCS scores, the standard deviations for the FIST variables appear fairly large relative to the mean, being similar to the findings by Clark, Pritchard and Woodward (2010) but unreported in other studies. Analyses of the *z*-scores show that all values lie within three standard deviations of the mean, while Figure 4.4 shows a mixed distribution, with a large number of low scores at or slightly above zero, and then a more even spread of values between a half and two-thirds of correct matches.

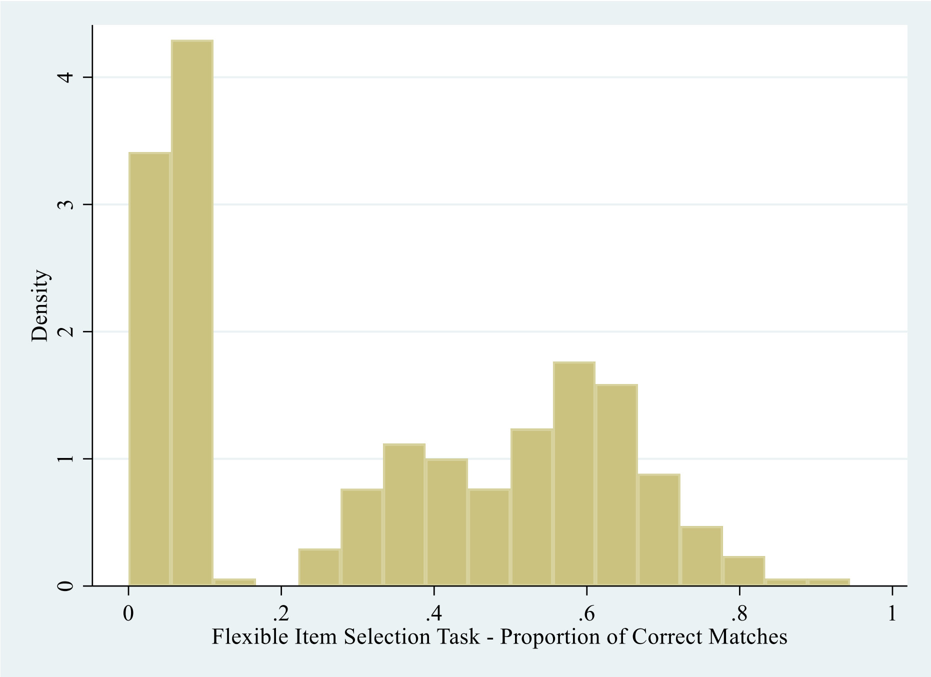


Figure 4.4 - Distribution of FIST Proportion Scores

Source: Primary data, 2018. Notes: This figure shows the distribution of Rwandan pupils' scores based on the total proportion of correct matches from the maximum number of responses across the task, excluding the criterial trials.

4.2.4 FIST Reliability

Like the DCCS, relatively few studies that use the FIST explicitly discuss or report on its reliability. Only Blair and Razza (2007) describe coefficients of .73 and .77 for American pre-school and kindergarten children respectively, while Dick (2014) indicates person and item reliabilities of .91.

To assess the reliability of the FIST in Rwanda, I calculated Cronbach's alpha to ascertain its inter-item internal consistency. The relevant coefficients for each round of the measure are set out in Table 4.5 below. Of particular note, the alphas for the 2-match trials and abstraction scores are somewhat low at .68 and .44 respectively, and below the .70 threshold which is widely considered as an acceptable minimum (Field, 2009). The low reliability for pupils' abstraction could affect the error in the model and the validity of the findings, but is not the main focus of the research, being learners' cognitive flexibility and shifting. Indeed, the shifting scores and 4-match rounds show good reliability with alpha coefficients in excess of .80.

Table 4.5 - FIST Reliability

Round/ Variable	Cronbach's Alpha	Items
2-match	.68	12
4-match	.85	24
Abstraction	.44	12
Shifting	.85	24
Overall	**.85**	**36**

Source: Primary data, 2018. Notes: The table sets out the alpha coefficients for each round of the FIST, the abstraction and shifting scores and the overall measure. The number of items is also specified.

In summary, the overall alpha of .85 represents good internal consistency and reliability, particularly in the context of executive function measurement. As noted in the previous chapter, even well-established tasks for assessing executive function can offer low internal and test-retest reliability (Blair, 2016; Miyake et al., 2000). Further, in the case of the FIST, asymmetries between the different dimensions can also undermine consistency across the items and a study by Ellefson et al. (2006) found that children were better able to match by colour than by shape.

4.2.5 Cognitive Flexibility Across the Measures

The histograms for the DCCS and FIST in Figures 4.3 and 4.4 respectively reveal that the respondents were broadly grouped into children who struggled to complete the tasks, often performing at floor, and those who displayed some aptitude and whose scores covered a range from medium to high achievement. To understand whether the same pupils fell into the same groups on different assessments, however, requires looking at the bivariate relationship between the two measures of cognitive flexibility.

Previous empirical studies from other contexts have used both parametric and non-parametric analyses to assess correlations between different measures of cognitive flexibility and thereby establish their reliability and convergent validity. Engel de Abreu et al. (2014), for example, found a statistically significant correlation of .23 ($p < .05$) between an adapted version of the DCCS and Opposite Worlds, another measure of cognitive flexibility, in a study among 6- to 8-year-olds in Brazil. Dick (2014) similarly compared American participants' performance on different rounds of the FIST with their scores on the WCST. He found inter-correlations in excess of .43 significant at the 0.10 per cent level ($p < .001$) between the various stages of the FIST[30], and statistically significant correlations ranging from .24 to .40 between the FIST scores and categories achieved on the WCST.

Podjarny et al. (2017) likewise used multiple measures to assess children's early cognitive flexibility. After collecting data from 107 pre-schoolers aged 3 and 4, they conducted non-parametric analyses which showed a statistically significant correlation between scores on the DCCS and those on the FIST (Kendall's tau-b (τ_B) = .23, $p < .01$). The DCCS but not the FIST results also showed a significant correlation with their new measure of cognitive flexibility, the Multidimensional Card Selection Task (MCST) (DCCS: $\tau_B = .27$, p < .01; FIST: $\tau_B = .14$, p > .05).

Correlational analyses between the DCCS and the FIST in the current study similarly help to establish the reliability and validity of the measures in the Rwandan context. Table 4.6 sets out the Pearson's correlation coefficient, *r*, for the different interactions and shows the magnitude of shared variance and strength of association between the variables (Ferguson, 2009). In each case, the correlations are positive and statistically significant at the 0.10 per cent level ($p < .001$). As one would expect, the scores on the same task are strongly correlated, .87 for the two DCCS variables and over .90 for the different FIST components, although with a lower correlation between abstraction and shifting at .80. Even *across* the measures, the relationships show reasonably strong associations with medium effect sizes ranging from .31 to .36 (Field, 2009)[31].

[30] Many correlations reduced after controlling for age in months but all remained statistically significant.
[31] Non-parametric analyses of the variables show similar levels of significant correlations.

Table 4.6 - Pearson's Correlation Coefficients for Cognitive Flexibility Measures

Variable	1.	2.	3.	4.	5.
1. DCCS Ordinal	1.00	-	-	-	-
2. DCCS Ratio (proportion)	.87***	1.00	-	-	-
3. FIST Proportion	.36***	.35***	1.00	-	-
4. FIST Abstraction	.33***	.31***	.93***	1.00	-
5. FIST Shifting	.35***	.34***	.96***	.80***	1.00

Source: Primary data, 2018. Notes: ***$p < .001$. The DCCS Ordinal score indicates the highest DCCS round that a pupil was able to successfully complete, while the DCCS Ratio (proportion) variable shows a child's proportion of correct post-switch matches across the task. The FIST Proportion score indicates the proportion of correct matches from the maximum number of responses across the task. FIST Abstraction indicates the proportion of correct *first* matches across the task, while FIST Shifting denotes the proportion of correct *subsequent* matches.

Beyond correlation coefficients, scatterplots can reveal further detail regarding the relationship between the two measures, although none of the published cognitive flexibility studies described above include such charts. Figure 4.5 shows pupils' FIST scores mapped against their proportion of correct DCCS matches, and displays several key features of the data. First, the line of best fit shows an overall positive association and correlation between the measures, which accords with the values in Table 4.6. Second, the diagram corroborates the grouping of responses on both measures, as evidenced by the absence of FIST values just below the .20 mark, and DCCS scores between .20 and .40. Indeed, the responses appear clustered into four discrete quadrants. Related to this, and despite the sizeable number of pupils who performed well on both assessments, there are many scores lying along the X- and Y-axes, which represent children who fared well on one task, but not the other.

The associations between the measures and these specific differences must therefore be interpreted in light of three important caveats. First, Podjarny et al. (2017) distinguish between different types of cognitive flexibility, *concurrent* and *sequential* or *switching* cognitive flexibility. Referring to the MCST and the DCCS, they explain that "the two aspects of cognitive flexibility measured in these tasks revealed distinct developmental patterns, supporting the view that cognitive flexibility is not composed of a single skill; rather, it consists of multiple conceptually related skills" (p. 204). In the current study, the FIST arguably draws on concurrent cognitive flexibility while the DCCS focuses predominantly on switching, so some variance between the scores is not surprising. Despite this distinction, the FIST shifting variable displays only slightly greater correlation with the ratio DCCS scores (r = .34) than the abstraction variable (r = .31), despite closer similarities in the cognitive processes involved.

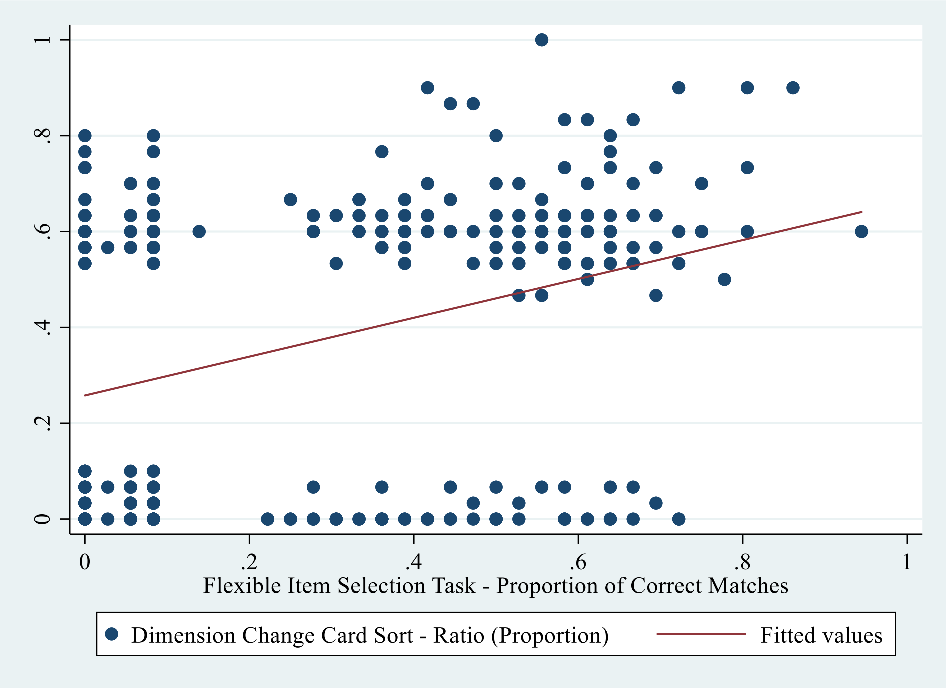


Figure 4.5 - Scatterplot of DCCS and FIST Scores

Source: Primary data, 2018. Notes: This figure shows performance on the FIST mapped against correct matches on the DCCS, including the line of best fit between the measures.

Second, the DCCS is a *deductive* measure of cognitive flexibility in which participants are explicitly told the rules by which they should sort the cards. By contrast, the FIST uses an *inductive* approach and demands that respondents determine the matching dimensions for themselves, hence the need to differentiate the abstraction and shifting scores (Jacques & Zelazo, 2001).

Finally, parametric analyses like Pearson's correlation coefficient make certain assumptions about the nature and distribution of the relevant data, as outlined in section 4.1.2 above. In summary, many assumptions are met but the sampling distributions do not appear to be normal, which may affect the degree of error in the findings. Nevertheless, the large size of the sample (n = 306) provides some comfort through the central limit theorem, which reduces the need for normality and allows analyses such as t-tests and regressions to still be valid (Lumley et al., 2002). Consequently, scores from both empirical measures can be used to analyse the related and overlapping aspects of cognitive flexibility but the findings must be treated with some caution.

4.3 Cognitive Flexibility Across Primary Cohorts

In addition to the measurement of cognitive flexibility, RQ1 also addresses the factors associated with its development during the course of Rwandan pupils' public primary education. Such factors may include formal schooling, or household or other environmental processes as highlighted in Figure 4.1 and the equation in section 4.1.1. Indeed, different influences may similarly hold varying importance at specific stages of a child's development.

The present study focuses on a cross-section of Rwandan learners in two grades, Primary 1 and Primary 4. In the absence of longitudinal data, differences between these cohorts may shed light on the diverse factors that shape pupils' cognitive flexibility. Literature discussed in Chapter 2 already emphasised the effects of children's maturation, whether this relates to their age or wider life experiences at school or in the home, however, such differences have not previously been tested in the Rwandan context. Table 4.7 therefore sets out descriptive statistics for learners' performance on the DCCS and the FIST, disaggregated by class grade.

Table 4.7 - DCCS and FIST Ratio Scores by Class Grade

Variable	Mean	Standard Deviation	Possible Range	Actual Range	95% Confidence Interval		*Z*-Score Range
DCCS Ratio (proportion)							
- Primary 1	.26	.29	0-1	0-.80	.21	.30	-1.26-1.36
- Primary 4	.51	.26	0-1	0-1	.47	.55	-1.26-2.01
FIST Proportion correct							
- Primary 1	.14	.18	0-1	0-.61	.11	.17	-1.20-1.14
- Primary 4	.48	.22	0-1	0-.94	.45	.52	-1.20-2.42

Source: Primary data, 2018. The DCCS Ratio (proportion) variable shows a child's proportion of correct post-switch matches across the task, while the FIST Proportion correct score indicates the proportion of correct matches from the maximum number of responses across the task.

In summary, the statistics indicate that pupils in Primary 4 typically performed better than those in Primary 1. For both measures, the mean is higher for the senior cohort and there is no overlap between the 95 per cent confidence intervals (CIs) for each grade. In terms of distribution, the standard deviations for the Primary 1 classes are larger than the respective means suggesting a wide range in performance among the younger learners. Between grades on the same task, however, there are only small differences in the standard deviations, which could suggest that the data meet the parametric assumption of homoscedasticity.

Graphical representations offer further insight on the differences between Primary 1 and Primary 4 and the histograms in Figures 4.6 and 4.7 show the Rwandan pupils' performance on each measure disaggregated by grade. In the case of the DCCS, the data for both groups appear bimodal, with discrete clusters of bars along the X-axis representing children who could and could not master the switching rules. Between the two graphs, a higher proportion of Primary 1 children feature at the bottom of the scale, while a larger number of Primary 4 children appear to have achieved at least the basic switches. The FIST charts show broadly similar trends of distribution, albeit with a greater spread of scores. There is, for example, a larger concentration of scores nearing floor among the Primary 1 children and a much higher proportion of correct matches within the Primary 4 cohort.

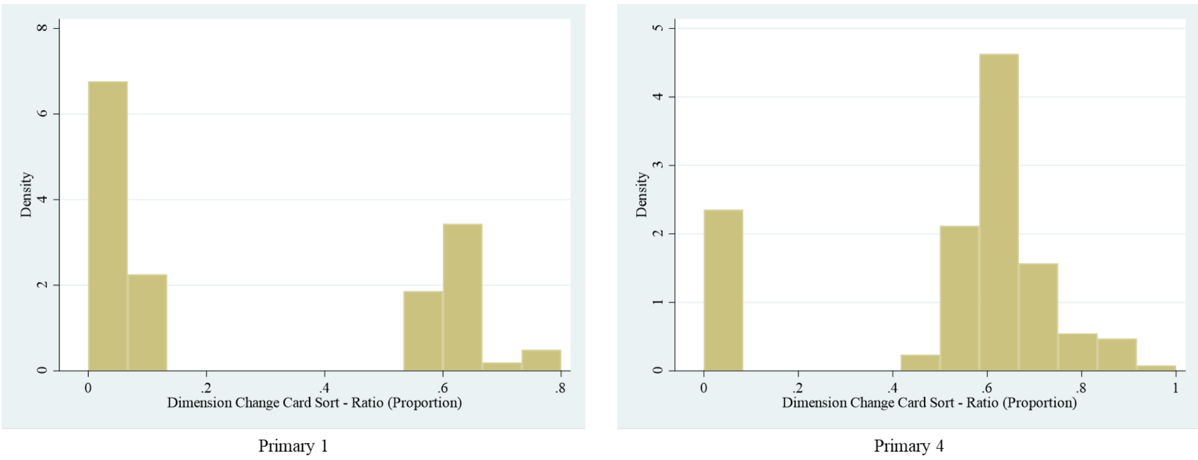


Figure 4.6 - Primary 1 and 4 Comparison of DCCS Scores

Source: Primary data, 2018. Notes: This figure shows the distribution of pupils' performance on the DCCS for each of Primary 1 and Primary 4.

Finally, statistical tests confirm the significance of the apparent differences between the scores of pupils in Primary 1 and Primary 4. An independent *t*-test using the proportion of children's correct responses on the DCCS indeed reveals that learners in Primary 4 (M = 0.51, standard error (SE) = 0.02, 95 per cent CI [0.47, 0.55]) on average performed better than those in Primary 1 (M = 0.26, SE = 0.02, 95 per cent CI [0.21, 0.30]). The difference, -0.26, is statistically significant, $t(304) = -8.03$, $p < .01$, and represents a large effect size, Cohen's d = 0.86. Similarly, pupils in the senior cohort achieved a higher proportion of correct matches on the FIST (M = 0.48, SE = 0.02, 95 per cent CI [0.45, 0.52]) than the younger children (M = 0.14,

SE = 0.01, 95 per cent [0.11, 0.17]). Again, the difference, -0.34, is statistically significant, $t(304) = -15.15$, $p < .01$, and represents a very large effect size, Cohen's d = 1.89[32].

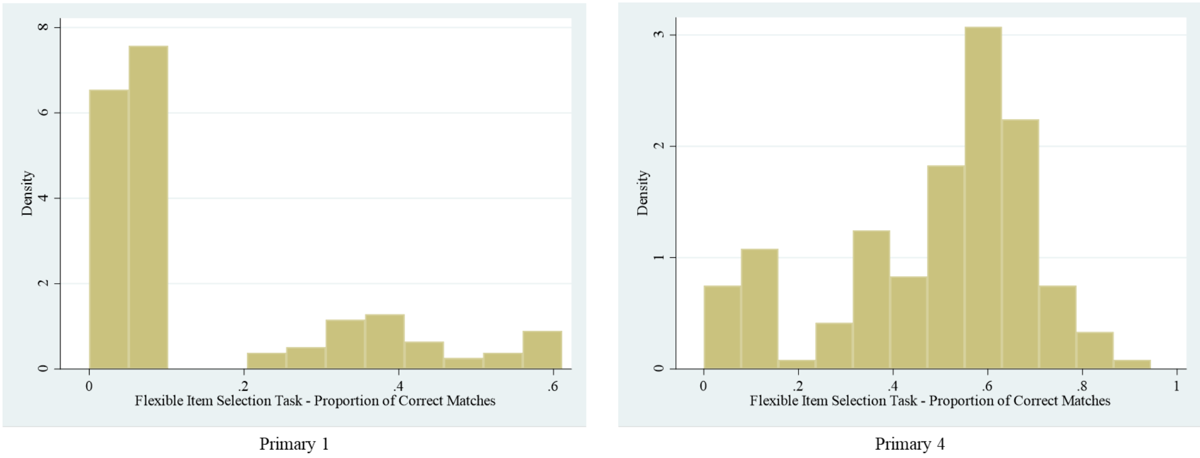


Figure 4.7 - Primary 1 and 4 Comparison of FIST Scores

Source: Primary data, 2018. Notes: This figure shows Rwandan children's performance on the FIST, disaggregated by class grade.

Overall, the data show improvements in Rwandan learners' cognitive flexibility between Primary 1 and Primary 4. However, such bivariate analyses offer little insight on the specific factors that drive this difference. As indicated above, the literature described in Chapter 2 suggests that these could be manifold and reflect a wide range of child-, home- and school-based characteristics. The next section therefore examines these factors in greater detail for each cohort and uses regressions to build them into more sophisticated models of cognitive flexibility development.

4.4 Background Characteristics and Cognitive Flexibility Regressions

In addition to the pupil assessments, the fieldwork team surveyed children on a diverse set of educational and background characteristics. Specific questions were informed by the conceptual framework set out in Figure 4.1 and investigated learners' prior schooling experiences, whether they attended pre-primary classes and, if so, what those lessons looked like. Similarly, the enumerators asked pupils about various family factors, for example, who the pupil lived with, what kind of house they lived in and how often they ate different sources of protein like meat and fish. The survey further examined proximal processes within the

[32] Non-parametric analyses of these differences using the Wilcoxon rank-sum (Mann-Whitney) test similarly revealed statistically significant differences between the cohorts' performances on the DCCS and the FIST.

household, whether anyone read with the child on a regular basis and whether they spoke multiple languages at home.

In each case, the survey questions were guided by empirical evidence and literature on factors shown to affect the development of executive function generally, or cognitive flexibility specifically. The questions were included not to look for causal relations, such as the *effect* of parental reading on cognitive flexibility, which would have necessitated a very different research design, but rather to unveil statistically significant variables that *could* help to understand the associations, if any, between cognitive flexibility and formal education.

4.4.1 Cognitive Flexibility in Primary 1

As a first step, I examined the data for statistically significant associations between Primary 1 pupils' cognitive flexibility and their responses to the survey questions. For the dependent variables, I used performance on the DCCS and FIST separately, as well as a combined cognitive flexibility score that drew on the proportion of correct matches on both tasks. Such measures show a medium correlation ($r = .35$, $p < .01$) and so were individually converted into z-scores with means of 0 and standard deviations of 1, and then averaged to generate a standardised, aggregated and continuous cognitive flexibility score[33] (Ellefson et al., 2017; Noble et al., 2005; Willoughby et al., 2019).

The choice of test depended on the type of predictor variable involved. These could be dichotomous, nominal or ordinal, and Table 4.8 below shows the different bivariate tests used for each kind of explanatory variable. Both parametric and non-parametric analyses were used on the basis that the data did not appear to meet all assumptions for the former that would allow for interpretation of the test statistics at face value. P-values were adjusted where appropriate using Bonferroni's procedure while *post hoc* tests revealed differences between the groups for nominal variables (Field, 2009).

[33] Alternative solutions for generating a combined cognitive flexibility score included factor analysis and item response theory. However, given that the DCCS and the FIST have already been widely used to measure cognitive flexibility with sub-tasks pre-grouped by difficulty, I followed the approach taken in numerous other executive function studies to average standardised scores across the assessments. Indeed, such approach is often used across different executive functions, such as working memory and inhibitory control, notwithstanding significant differences in the cognitive processes involved (Wolf & McCoy, 2019).

Table 4.8 - Tests for Explanatory Variables

Variable Type	Parametric	Non-Parametric
Dichotomous	Independent *t*-test	Wilcoxon Rank-Sum Mann-Whitney
Nominal	Analysis of Variance (ANOVA)	Kruskal-Wallis
Ordinal	Pearson's Correlation Coefficient	Spearman's Rank Correlation Coefficient

Source: Field, 2009. Notes: This figure shows the appropriate bivariate tests for parametric and non-parametric analyses to explore significant associations between predictor variables and measures of cognitive flexibility.

Table 4.9 below sets out the findings from such analyses and specifically indicates whether each predictor variable showed a statistically significant relationship with one or more measures of cognitive flexibility. In each case, the variables are grouped according to the categories set out in Figure 4.1, being maturational or child-level characteristics, as well as environmental and educational factors. Several variables relating to the conditions of the assessment, for example whether it was conducted during the morning or afternoon session, are also included in a fourth category. Appendix 11 provides full details of the tests involved and their specific results.

The tests show a range of different predictor variables with statistically significant relationships to Primary 1 pupils' cognitive flexibility. First, regarding child-level characteristics, the learner's age was significantly associated with his or her attainment across the tasks, which accords with considerable literature about the effects of children's maturation on their cognitive flexibility (Bellaj et al., 2016; Cook et al., 2019; Dick, 2014; Frye et al., 1995). However, there were no significant differences according to gender, with girls and boys achieving similar scores on both measures.

Table 4.9 - Explanatory Variables and Primary 1 Pupils' Cognitive Flexibility

Variables Showing Statistical Significance	Variables Not Showing Statistical Significance
Maturational/Child-level Factors	
Pupil age	Gender
Environmental Factors	
Drank before school; Meals per day; Sees grandmother reading; Family environment/stress	Ate before school; Sees mother, father, brother, sister, grandfather, uncle, aunt, cousin, non-relative guardian, other family member reading at home; Family structure; House type; Frequency eating meat, fish, eggs; Frequency drinking milk; Multilingual household; Frequency of family reading; Reading with child; Books at home; Number of family readers
Educational Factors	
Years of pre-primary; Years of prior schooling	Private tuition; School district; 'High-performing' school; Repeated any primary; Attended any pre-primary; Pre-primary type; Private tutor; School; Years of repeated primary; Years of prior primary
Assessment Factors	
Enumerator	Test co-enumerated; Afternoon assessment

Source: Primary data, 2018. Notes: This table shows which explanatory variables displayed statistically significant associations with one or more measures of cognitive flexibility among Primary 1 children. Significances are calculated at the 5 per cent level ($p < .05$).

The environmental and household factors revealed somewhat more surprising findings. The number of meals a child reported eating in an average day and whether he or she claimed to have drunk anything before attending school were both significantly related to their cognitive flexibility performance. However, in contrast to literature on the *positive* association between children's SES and their executive function development, the Primary 1 learners who ate more meals and reported drinking before school scored *worse* on the DCCS. There is nevertheless some, albeit limited, research which suggests that children from more disadvantaged contexts and adults with diffuse attention[34] may perform better than their peers on tasks testing their creative problem solving, divergent thinking and other types of mental flexibility (Amer et al., 2016; Dahlman et al., 2013; Howard et al., 2020; Mittal et al., 2015).

Two further household variables showed statistically significant relationships with one or both measures of cognitive flexibility. First, bivariate analyses revealed that Primary 1 pupils who reported seeing their grandmothers reading at home performed significantly better than others on the DCCS (z = -2.26, p = .02) but worse on the FIST (t = 10.05, p < .01). By way of

[34] Such condition is seen as displaying some of the same executive function characteristics as those observed among poor children.

explanation, grandmothers' reading could point at higher educational attainment within the home, or a greater culture of literacy and learning transmitted between the generations. However, not all children reported grandparents living at home which creates a potentially imbalanced comparison and the number of pupils who saw their grandmothers reading ($n = 2$) was too small to offer any meaningful statistical significance.

Second, there appeared to be a significant association between Primary 1 learners' cognitive flexibility and the tone of their home environment, specifically whether it appears to provide a more stressed or nurturing family setting. However, *post hoc* analyses revealed that the only significant difference lay between pupils who reported living in more stressful homes and those that declined to answer the question. By contrast, there was no material variation between learners from stressed versus affectionate households. Further, the difference concerned only four pupils from Primary 1 who refused to answer the question, each of whom performed at floor on one or both measures of cognitive flexibility, which again suggests that the sample is too small to offer a meaningful statistical finding.

Regarding educational factors, only learners' years of pre-primary education and overall prior schooling showed any significant association with their cognitive flexibility. Once again, however, the results were somewhat counterintuitive. In both cases, the number of years was *negatively* related to pupils' cognitive flexibility scores. This could suggest that learners become *less* flexible through exposure to schooling but a more plausible explanation is that children in Primary 1 who have already spent at least some time in formal education are more likely to have repeated previous years and may therefore be slower learners.

Finally, despite rigorous training and ongoing monitoring, pupils undertaking the assessments with one particular enumerator scored consistently higher than their peers, $F(3, 149) = 3.78$, $p = .01$. Some of this variation could feasibly be explained by research team members testing different numbers of Primary 1 children across the four schools, or indeed the specific enumerator inadvertently adapting the instructions, which gave rise to unintentional advantages for her participants and additional error in the scores.

Building on these analyses and to move beyond mere associations, I conducted multivariate regressions with the key variables to predict cognitive flexibility performance among Primary 1 pupils in the participating schools. Specifically, I used the combined cognitive flexibility score as the outcome variable and followed the approach taken by Clark et al. (2010) to use $p < .10$ as the criterion for including variables in the regression model. In addition to the significant factors described above, this admitted two further variables: how frequently a child reported eating fish; and whether or not he or she had attended any form of pre-primary education[35]. Pupils' schools were also included as a nominal variable in the model, not least to control for the effects of any enumerator testing a higher number of Primary 1 learners in any specific institution.

As described above, several discrete variables relating to children's previous schooling experiences showed statistically significant associations with Primary 1 pupils' cognitive flexibility at the $p < .10$ level: their years of pre-primary education (ordinal); their years of overall prior schooling (ordinal); and whether or not they attended any form of pre-primary education (dichotomous or dummy). These three variables, although different, are closely related, for example, learners' years of prior education which draws on both their pre-school experiences and any previous years already spent in Primary 1. In which case, to avoid multicollinearity and to maximise their unique variance, I only included the first variable, pupils' years of pre-primary education, in the regression together with a dummy variable for whether he or she had repeated any years in Primary 1.

The regression was conducted using forced entry to include all variables into the model simultaneously (Field, 2009). Table 4.10 below sets out the key statistics, in particular the beta coefficients (*b*), SE, standardised betas (β), *p*-values and 95 per cent CIs. Overall, the regression shows a reasonable level of fit, $F(12, 138) = 2.21$, $p = .01$, with the R^2 value signifying that the model explains 16 per cent of the variance in Primary 1 pupils' cognitive flexibility, which drops to 9 per cent when adjusted for the number of variables (the adjusted R^2). Of greater note, however, is the lack of statistical significance for *any* of the explanatory variables. In each case, the *p*-values exceed .05 and suggest that none of the variables accurately predicted Primary 1 pupils' cognitive flexibility at the 95 per cent confidence level, although learners' age, their reported frequency of eating fish and whether they drank anything before school showed statistical significance at the 90 per cent confidence level.

[35] The kind of house pupils reported living in also showed statistical significance with their performance on the DCCS. However, post hoc analyses revealed that, again, the statistical difference concerned a small number of children ($n = 2$) who declined to answer the question, yet performed above the average. Given the small number involved, such variable was therefore omitted from the regression model.

Table 4.10 - Multivariate Regression for Primary 1 Pupils' Cognitive Flexibility Scores

	b	SE	*β*	*p*	95 per cent CIs	
Pupil age	0.21	0.11	0.15	.06	-0.01	0.43
Drank before school	-0.19	0.11	-0.15	.09	-0.41	0.03
Meals per day	-0.04	0.08	-0.04	.63	-0.20	0.12
Frequency of eating fish	-0.07	0.04	-0.15	.08	-0.15	0.01
Years of pre-primary	-0.03	0.03	-0.07	.41	-0.09	0.04
Repeated any primary	-0.01	0.11	-0.01	.90	-0.23	0.20
School						
- School 2	0.02	0.18	0.02	.89	-0.33	0.38
- School 3	-0.07	0.19	-0.05	.73	-0.45	0.32
- School 4	0.00	0.15	0.00	.98	-0.28	0.29
Enumerator						
- Enumerator 2	0.28	0.18	0.20	.14	-0.09	0.64
- Enumerator 3	0.01	0.15	0.01	.95	-0.29	0.31
- Enumerator 4	-0.02	0.21	-0.01	.93	-0.44	0.40
Constant	-1.72*	0.84	-	.04	-3.39	-0.05

Source: Primary data, 2018. $^*p < .05$. Notes: This table shows the results of a multiple regression for Primary 1 pupils' cognitive flexibility, using a combined score from both the DCCS and FIST measures. b = regression coefficient for each predictor variable, SE = standard error, β = standardised beta, CI = confidence interval.

In summary, relatively few of the explanatory variables captured for younger Rwandan learners showed statistically significant relationships with their cognitive flexibility, and none reliably predicted their performance on the measures used[36]. This could be due to several reasons. First, the factors highlighted as important by researchers in Western settings may hold reduced significance in the Rwandan context and the study might have omitted to capture data on the *real* determinants of Rwandan cognitive flexibility, at least among children aged 7 and 8. Alternatively, the survey questions and measurement could have failed to accurately and reliably capture the *processes* by which such factors nurture cognitive flexibility among Rwandan learners. Finally, the reduced sample size (n = 153) might have been too small to

[36] Logistic regressions using the same predictors and binary variables for each measure of cognitive flexibility separately revealed similar findings, with assessment by a particular enumerator comprising the only statistically significant explanatory variable for the DCCS only.

provide sufficient statistical power to detect the differences. The findings for Primary 4 students may nevertheless indicate which of these explanations holds the most weight.

4.4.2 Cognitive Flexibility in Primary 4

The histograms in Figures 4.6 and 4.7 showed that among Primary 1 pupils there was a relatively clear delineation between children who could and could not display at least a basic level of cognitive flexibility. By contrast, the scores for Primary 4 learners revealed greater variation and a wide range from children who struggled to achieve the basic matches, to those who achieved an average level of performance, and even some who paired most or even all of the stimuli perfectly.

Noting this granularity, I undertook the same approach for the Primary 4 data as for the Primary 1 children. Specifically, I conducted the bivariate analyses outlined in Table 4.8 using the DCCS, FIST and combined cognitive flexibility scores as the dependent variables. Appendix 11 sets out the full results while Table 4.11 below shows the significance of each variable, once again grouping the factors according to the themes set out in Figure 4.1.

The results show that neither of the main child-level characteristics was significantly associated with their cognitive flexibility. Whether the Primary 4 learners were male or female, or aged 10 or 11 displayed no relation to differences in their performance. Regarding background factors, however, children's family structures at home *did* show significant associations with their cognitive flexibility scores. In particular, pupils from single-parent families (n = 41) performed better than those from two-parent households (n = 101), in direct contrast to the findings of a study by Sarsour et al. (2011) with 8-10-year-olds in North America.

Table 4.11 - Explanatory Variables and Primary 4 Pupils' Cognitive Flexibility

Variables Showing Statistical Significance	Variables Not Showing Statistical Significance
Maturational/Child-level Factors	
-	Pupil age; Gender
Environmental Factors	
Family structure; Sees aunt reading at home; Reading with child	Ate before school; Sees mother, father, brother, sister, grandfather, uncle, cousin, non-relative guardian, other family member reading at home; House type; Frequency eating meat, fish, eggs; Frequency drinking milk; Multilingual household; Frequency of family reading; Reading with child; Books at home; Number of family readers; Drank before school; Meals per day; Sees grandmother reading; Family environment/stress
Educational Factors	
School district; School; Private tutor; Pre-primary type	Private tuition; 'High-performing' school; Repeated any primary; Attended any pre-primary; Pre-primary type; Years of repeated primary; Years of prior primary; Years of pre-primary; Years of prior schooling
Assessment Factors	
Enumerator	Test co-enumerated; Afternoon assessment

Source: Primary data, 2018. Notes: This table shows which explanatory variables displayed statistically significant associations with one or more measures of cognitive flexibility among Primary 4 children. Significances are calculated at the 5 per cent level ($p < .05$).

Two further environmental variables showed statistically significant results but with too few observations to offer meaningful findings. First, learners who reported seeing their aunts read at home scored significantly worse than other Primary 4 pupils. However, as with grandmothers' reading for Primary 1 children, this makes for an unequal comparison as very few pupils across the whole sample (n = 9) mentioned their aunts living at home and only two Primary 4 learners reported such practices. Second, children who described rarely reading with family members performed worse not just than learners who reported regular reading with their guardians, but also those who claimed to never read with family members. Again, the small number of observations (n = 2) suggests that such results offer little meaningful insight.

Rather, a higher number of *educational* factors showed statistical significance for Primary 4 learners' cognitive flexibility than their younger counterparts. This would make sense since the older pupils had been exposed to the effects formal education for at least 3 additional years. Most noticeably, both *t*-tests and ANOVAs revealed that Primary 4 children selected from the two schools in Nyarugenge district performed significantly better than those in the Gasabo schools, $t(151) = 3.41$, $p < .01$, $r = 0.27$.

Other statistically significant variables concerned the identity of personal tutors and the format of learners' pre-primary education. Specifically, Primary 4 children receiving private tuition from teachers at their own school or other tutors performed better than those who were tutored by teachers from other schools, $F(2, 17) = 4.82$, $p = .02$. However, the total number of pupils who claimed to be tutored overall was fairly small ($n = 20$) relative to the main sample. Similarly, the results suggest that Primary 4 learners who experienced basic childcare by way of pre-primary education showed lower cognitive flexibility than those in both formal classrooms and who did not attend pre-school, however, such finding is based on one observation only and so can be discounted for further analytical purposes.

Finally, as with the Primary 1 data, the particular enumerator undertaking an assessment emerged as significantly associated with pupils' cognitive flexibility scores in two instances. Specifically, children completing the tasks with the same research assistant discussed above scored higher on one measure of cognitive flexibility than those taking the test with another, whose pupils in turn outperformed those of a different enumerator on the second cognitive flexibility task. Overall, these results do not show a consistent pattern of advantage or association across both measures of cognitive flexibility.

However, to ascertain the predictive effect of these and other variables, I conducted a multivariate regression for the Primary 4 pupils, again using the combined cognitive flexibility score as the outcome variable. As before, I applied a criterion of $p < .10$ for incorporating variables into the regression model (Clark et al., 2010). This precipitated the inclusion of the following additional factors: the type of house children reported living in; the family environment, whether stressful or nurturing; whether multiple languages were spoken at home; how frequently pupils saw family members reading; and the reported number of household readers. Whether children saw their uncles and brothers reading at home was also statistically significant with cognitive flexibility scores at the 90 per cent level, however, such variables were excluded based on the low number of observations. Similarly, the district variable was omitted on account of its high collinearity with the specific schools, as was the identity of tutors because so few children reported receiving private tuition.

Table 4.12 below sets out the regression statistics, once again conducted using forced entry (Field, 2009). Generally, the regression shows an acceptable level of fit, $F(15, 133) = 2.20$, $p = .01$, and explains 20 per cent of the variance in Primary 4 pupils' cognitive flexibility (R^2), or 11 per cent when adjusted for the number of variables (the adjusted R^2). The results also show two key areas where the beta coefficients are statistically significant. First, the statistics confirm that a Primary 4 child's family structure is predictive of his or her cognitive flexibility, b = 0.29 [0.06, 0.52], β = 0.21, p = .02. Specifically, this means that learners from single-parent families achieved 29 per cent of a standard deviation in the cognitive flexibility score higher than children from two-parent families, holding all other variables constant. As indicated above, this is in direct conflict with the findings by Sarsour et al. (2011) who found that two-parent families otherwise mitigated the effect of American children's low SES.

Second, Table 4.12 reveals that the school learners attended also predicted their cognitive flexibility. Pupils in School 3 and School 4 scored 51 and 52 per cent of a standard deviation respectively *lower* than children in School 1, after controlling for other factors (School 3: b = -0.51 [-0.83, -0.18], β = -0.35, p < .01; School 4: b = -0.52 [-0.84, -0.20], β = -0.35, p < .01). By contrast, there were no significant differences between Schools 1 and 2, both being located in Nyarugenge district.

Unlike the findings from the Primary 1 data, these results show that certain household and educational factors did indeed predict cognitive flexibility scores among Primary 4 learners. On the one hand, children from single-parent families scored higher than those living with two parents, which could suggest greater adaptability and resilience for learners experiencing instability or unpredictability in other parts of their lives. On the other hand, there were clear differences in cognitive flexibility scores based on the particular school pupils attended, which could suggest the importance of some educational methods or pedagogical practices. How these factors interact with learners' age and class grade however remains unclear, and comprises the focus of the next section.

Table 4.12 - Multivariate Regression for Primary 4 Pupils' Cognitive Flexibility Scores

	b	SE	*β*	*p*	95 per cent CIs	
Family structure						
- Non-relative guardian(s)	-0.47	0.63	-0.06	.46	-1.72	0.78
- Non-parent family guardian(s)	0.29	0.22	0.11	.19	-0.14	0.71
- Single parent family	0.29*	0.12	0.21	.02	0.06	0.52
Family environment (stress)	-0.16	0.17	-0.08	.34	-0.50	0.17
Multilingual household	0.03	0.04	0.05	.52	-0.06	0.11
Frequency of family reading	0.00	0.04	0.00	.99	-0.08	0.07
Number of family readers	0.03	0.15	0.03	.87	-0.28	0.33
House type						
- Basic house	0.01	0.16	0.00	.97	-0.31	0.33
- Large house	-0.17	0.11	-0.12	.15	-0.39	0.06
School						
- School 2	-0.25	0.17	-0.18	.14	-0.59	0.08
- School 3	-0.51**	0.16	-0.35	.00	-0.83	-0.18
- School 4	-0.52**	0.16	-0.35	.00	-0.84	-0.20
Enumerator						
- Enumerator 2	0.06	0.19	0.04	.76	-0.32	0.44
- Enumerator 3	-0.08	0.15	-0.06	.58	-0.39	0.22
- Enumerator 4	-0.22	0.19	-0.16	.25	-0.60	0.16
Constant	0.88***	0.22	-	.00	0.45	1.31

Source: Primary data, 2018. **p* < .05, ***p* < .01. Notes: This table shows the results of a multiple regression for Primary 4 pupils' cognitive flexibility, using a combined score from both the DCCS and FIST measures. *b* = regression coefficient for each predictor variable, SE = standard error, *β* = standardised beta, CI = confidence interval.

4.4.3 A Combined Model for Cognitive Flexibility

The regressions summarised in Tables 4.10 and 4.12 revealed that relatively few explanatory variables predicted cognitive flexibility scores among Rwandan learners in Primary 1 and Primary 4 classrooms respectively. These findings stand in stark contrast to the marked differences in distributions *between* such cohorts as shown in Figures 4.6 and 4.7. I therefore combined data from all pupils and conducted regressions to estimate differences in cognitive flexibility between children in Primary 1 and Primary 4, conditional on the environmental and educational factors showing statistically significant associations.

First, I ran a simple regression using the Rwandan learners' grade, Primary 1 or Primary 4, as a sole dichotomous variable. Table 4.13 shows the key statistics, which indicate a good level of fit, $F(1, 304) = 228.13$, $p < .01$. Specifically, the R^2 value indicates that the model explains 43 per cent of pupils' cognitive flexibility variance, and that their class grade alone accounted for a difference of more than one standard deviation on the cognitive flexibility measure.

Table 4.13 - Simple Regression between Cognitive Flexibility and Pupil Class Grade

	b	SE	*β*	*p*	95 per cent CIs	
Class grade	1.07***	.07	0.65	.00	0.93	1.21
Constant	-0.54***	.05	-	.00	-0.64	-0.44

Source: Primary data, 2018. ***$p < .001$. Notes: This table shows the results of a multiple regression for Rwandan pupils' cognitive flexibility, using a combined score from both the DCCS and FIST measures and the learners' class grades. b = regression coefficient for each predictor variable, SE = standard error, β = standardised beta, CI = confidence interval.

Next, I ran a multivariate regression which incorporated the child-level and background factors showing significant bivariate relationships with one or more measures of cognitive flexibility at the 90 per cent confidence level (Clark et al., 2010). Pupils' ages, despite being statistically significant for Primary 1 respondents, were excluded from the regression for reasons of multicollinearity. Specifically, participants were sampled by both grade *and* age as described in Chapter 3, and so to include both variables would have prevented the determination of either predictor's unique contribution or variance.

Table 4.14 sets out the results of the regression. Overall, the model shows an improved level of fit, $F(13, 280) = 18.11$, $p < .01$, with the R^2 value increasing to explain 46 per cent of the variance in pupils' cognitive flexibility. This figure nevertheless reduces to 43 per cent when adjusted for the number of variables (the adjusted R^2). Similar to the simple regression, the model shows that learners' class significantly predicted their cognitive flexibility scores, albeit with a slightly reduced beta coefficient, after controlling for all other variables. However, the kind of house pupils reported living in also predicted their outcomes with children from larger houses performing worse on the cognitive flexibility measures than their peers in more average houses, $b = -0.18$ [-0.35, -0.02], $\beta = -0.11$, $p = .03$. Compared with children who reported living in a medium-sized house, pupils from seemingly more affluent homes scored 18 per cent of a standard deviation *lower* on the combined cognitive flexibility score, holding other factors constant including learners' class grade.

Table 4.14 - Linear Model of Background Predictors of Cognitive Flexibility

	b	SE	*β*	*p*	95 per cent CIs	
Class grade	1.03***	0.08	0.63	.00	0.87	1.19
Family structure						
- Non-relative guardian(s)	-0.54	0.64	-0.04	.40	-1.79	0.72
- Non-parent family guardian(s)	0.22	0.16	0.06	.18	-0.10	0.54
- Single parent family	0.14	0.09	0.08	.10	-0.03	0.31
Drank before school	-0.12	0.08	-0.07	.13	-0.28	0.04
Meals per day	-0.01	0.06	-0.01	.83	-0.13	0.11
Frequency of eating fish	0.00	0.03	0.00	.92	-0.06	0.06
Family environment (stress)	0.00	0.10	0.00	.98	-0.19	0.19
Multilingual household	0.04	0.03	0.06	.18	-0.02	0.10
Frequency of family reading	0.00	0.03	0.00	.99	-0.07	0.07
Number of family readers	0.00	0.14	0.00	.99	-0.28	0.28
House type						
- Basic house	-0.12	0.12	-0.05	.29	-0.35	0.11
- Large house	-0.18*	0.08	-0.11	.03	-0.35	-0.02
Constant	-0.37*	0.16	-	.02	-0.68	-0.05

Source: Primary data, 2018. $*p < .05$, $***p < .001$. Notes: This table shows the results of a multivariate regression for Rwandan pupils' cognitive flexibility, using a combined score from both the DCCS and FIST measures and significant environmental and household explanatory variables. *b* = regression coefficient for each predictor variable, SE = standard error, *β* = standardised beta, CI = confidence interval.

In the final regression, I added variables relating to pupils' education, both pre-school and primary, as well as significant factors concerning the administration of the assessment. As with the Primary 1 regression, the number of years of prior schooling learners reported was excluded, given its high collinearity with their years of pre-primary, but I included a dummy variable for whether they had repeated any years in primary. Similarly, the district variable was omitted on the basis of collinearity with the specific school a child attended.

The statistics for this third regression are set out in Table 4.15 and show a good level of fit, $F(21, 272) = 12.42$, $p < .01$. Introducing the educational factors improved the R^2 from .46 to .49, signifying that the model explains 49 per cent of the cognitive flexibility variance. The adjusted R^2 value also increases to .45, notwithstanding the additional number of variables, and the regression model appears to meet the underlying assumptions for parametric analysis, such as the need for homoscedasticity, as described in Appendix 12.

The results confirm and corroborate several findings from the previous regressions. First, a learners' class grade comprises the most significant predictor of his or her cognitive flexibility score, $b = 1.04$ [0.87, 1.20], $\beta = 0.63$, $p < .01$. Indeed, its beta coefficient actually *increases* slightly with the inclusion of the additional explanatory variables. Second, pupils' house type remains significant, with those from reportedly larger homes scoring 17 per cent of a standard deviation *lower* than their peers from average-sized houses, holding other factors constant, $b = -0.17$ [-0.34, -0.01], $\beta = -0.11$, $p = .04$. Finally, learners from School 3 performed significantly worse than children in School 1, after controlling for all other factors, $b = -0.34$ [-0.59, -0.09], $\beta = -0.18$, $p = .01$.

In summary, the regressions reveal several significant factors, both environmental and educational, which predicted Rwandan children's performance on the cognitive flexibility measures. The full model also explains 49 per cent of the variance in learners' scores, or 45 per cent once adjusted for the number of explanatory variables.

Table 4.15 - Linear Model of Background and Educational Predictors of Cognitive Flexibility

	b	SE	*β*	*p*	95 per cent CIs	
Class grade	1.04***	0.08	0.63	.00	0.87	1.20
Family structure						
- Non-relative guardian(s)	-0.42	0.63	-0.03	.51	-1.67	0.83
- Non-parent family guardian(s)	0.17	0.16	0.05	.31	-0.16	0.49
- Single parent family	0.09	0.09	0.05	.31	-0.08	0.26
Drank before school	-0.11	0.08	-0.06	.19	-0.26	0.05
Meals per day	-0.03	0.06	-0.02	.68	-0.15	0.10
Frequency of eating fish	-0.02	0.03	-0.03	.54	-0.08	0.04
Family environment (stress)	-0.03	0.10	-0.01	.78	-0.22	0.16
Multilingual household	0.04	0.03	0.06	.20	-0.02	0.10
Frequency of family reading	0.01	0.03	0.03	.77	-0.06	0.08
Number of family readers	-0.05	0.14	-0.04	.70	-0.33	0.22
House type						
- Basic house	-0.11	0.12	-0.04	.36	-0.34	0.13
- Large house	-0.17*	0.08	-0.11	.04	-0.34	-0.01
Years of pre-primary	-0.02	0.02	-0.04	.44	-0.06	0.03
Repeated any primary	0.04	0.08	0.02	.60	-0.11	0.19
School						
- School 2	-0.15	0.13	-0.08	.22	-0.40	0.09
- School 3	-0.34**	0.13	-0.18	.01	-0.59	-0.09
- School 4	-0.17	0.11	-0.09	.13	-0.39	0.05
Enumerator						
- Enumerator 2	0.08	0.13	0.04	.54	-0.18	0.35
- Enumerator 3	-0.04	0.11	-0.02	.74	-0.26	0.18
- Enumerator 4	-0.22	0.15	-0.12	.13	-0.51	0.06
Constant	-0.06	0.23	-	.80	-0.51	0.40

Source: Primary data, 2018. $*p < .05$, $**p < .01$, $***p < .001$. Notes: This table shows the results of a multivariate regression for Rwandan pupils' cognitive flexibility, using a combined score from both the DCCS and FIST measures and significant environmental and educational explanatory variables. b = regression coefficient for each predictor variable, SE = standard error, β = standardised beta, CI = confidence interval.

4.5 Discussion

The preceding sections described the use of two psychological tasks to measure children's cognitive flexibility in Rwanda for the first time, and thereby identify significant factors associated with its development. Using primarily parametric analyses, they identified variables showing statistically significant associations and then employed linear regressions to predict the children's performance at Primary 1 and 4 levels, and then across both school cohorts. Throughout this process, the study aimed to uncover related factors rather than unpick causal mechanisms, and so the findings must be interpreted in light of this limitation.

First, the data show that cognitive flexibility can indeed be measured among Rwandan learners using established assessments such as the DCCS and the FIST, adapted for the particular context. As outlined in Chapter 3, the adaptations were fairly minimal and merely involved changing the stimuli shapes to images that would be more easily recognisable for Rwandan pupils, from boats and teapots to goats and motorcycles. Many researchers in Western settings also now use computerised versions of the tasks, however, the current study demonstrates that more traditional formats with children sorting physical cards can still generate reliable and valid data in lower-income environments.

Between the two measures, bivariate analyses revealed a positive and medium correlation (r = .35, p < .01). This suggests that the DCCS and FIST assess the same underlying construct, cognitive flexibility, albeit potentially slightly different aspects (Dick, 2014; Engel de Abreu et al., 2014; Podjarny et al., 2017). However, the data also highlight the risks of comparing learners' performance across diverse contexts and the limitations of accepted 'knowledge' on when children should be able to achieve certain developmental milestones. Indeed, fewer 7-year-old Rwandans completed the basic DCCS switch than would be expected from North American benchmarks, and this may arguably call into question the external validity and global generalisability of so many studies based on narrow and privileged sampling populations (Schulson, 2020).

Beyond the measurement of cognitive flexibility, the present research also identifies several significant factors that predicted its development among the Rwandan learners. At the Primary 1 level, no factors emerged as significantly predicting pupils' cognitive flexibility, however, Primary 4 children from single-parent families and attending schools in Nyarugenge district performed better than their peers, holding other variables constant.

Across the cohorts, the linear regressions identified the house children reported living in as being the key environmental factor significantly associated with their cognitive flexibility scores. Pupils claiming to live in larger houses overall scored 17 per cent of a standard deviation *less* than those from more average homes, controlling for all other factors. As noted above, there is some limited international research on disadvantaged children displaying increased creative problem-solving skills, which could hint at possible cognitive compensatory advantages or poverty breeding adaptability and resilience out of necessity (Dahlman et al., 2013; Mittal et al., 2015). This too could potentially explain the significance of single-parent families for learners in Primary 4.

However, none of the analyses for the combined cognitive flexibility scores or the DCCS or FIST datasets separately revealed any significant differences in the other house-related comparisons. Specifically, there were no performance differences between children living in the most basic houses and those from either the average-sized or the larger houses. Of course, there is the possibility that pupils answered the question inaccurately, choosing the more socially desirable response, which would itself point at some basic cognitive flexibility in the assumption of a different perspective (Schulz, 2005). Similarly, the children might have had difficulties in distinguishing key characteristics of the example houses, shown in Figure 4.8, and relating them to their own homes. If there was a material relationship between pupils' poverty and their cognitive flexibility, either positive or negative, more poverty-related variables would likely have shown statistically significant associations.

Figure 4.8 - Pupil House Responses

Overall, educational factors, particularly children's class and school, displayed more prominent relationships with their cognitive flexibility. In particular, holding other factors constant, the difference between Primary 1 and Primary 4 accounted for an additional 1.04 standard deviations on children's cognitive flexibility scores. However, high levels of multicollinearity and the mixed sampling approach meant that the regressions could not isolate the contribution of years of primary schooling from the maturational effect of learners' ages. Such analysis would have required counterfactual data from similarly aged but out-of-school children, or testing pupils of different ages with comparable levels of previous schooling. As such, the regression coefficient may include some variance attributable, at least in part, to the learners' ages.

Indeed, much of the literature to date examining children's cognitive flexibility worldwide has focused on the key role of age and interactions with other aspects of executive function development (Bellaj et al., 2016; Best et al., 2011; Dias et al., 2013; Jacques & Zelazo, 2001). This is in part because the majority of studies have taken place in high-income contexts where both primary schooling and pre-primary education are assumed. Even international studies in more diverse settings have tended to focus on pre-school participants, between the ages of 2 and 6, when most children supposedly start to show evidence of deliberate switching and flexibility (Blakey et al., 2016; Carlson, 2005; Hongwanishkul et al., 2005; Mwaura et al., 2008; Willoughby et al., 2019).

Beyond class grade, the particular school learners attended also showed significant associations with their cognitive flexibility outcomes. Among Primary 4 pupils, children attending in Gasabo district scored 51-52 per cent of a standard deviation less than those in the Nyarugenge schools. Even across the cohorts, learners in School 3 performed 34 per cent of a standard deviation lower than pupils in School 1, holding all other factors constant.

To summarise and answer RQ1, this chapter has demonstrated that cognitive flexibility can be effectively and reliably measured among Rwandan children using adapted versions of the DCCS and FIST. The assessments tap slightly different aspects of cognitive flexibility and were initially designed in higher-income settings, however, the current research shows that they can be modified for successful use in Rwandan schools. In terms of associations, no factors significantly predicted the Primary 1 learners' cognitive flexibility but the school Primary 4 pupils attended and their family structure displayed significant relationships with their performance on the tasks. Across the cohorts, children's school and class grade showed the most robust associations, with the older learners scoring significantly higher than the younger pupils, even after controlling for other variables.

In conclusion, the precise contribution of schooling to Rwandan children's cognitive flexibility development remains unclear, over and above the effects of natural maturation and growing up. Differences in teachers' attitudes, behaviours or practices could account for some variation between schools, and these are explored in detail in Chapters 6 and 7. Similarly, cognitive flexibility development could vary with learners' progress towards the acquisition of more traditional academic skills like literacy and reasoning. This begs questions around if and how changes in cognitive flexibility relate to other educational outcomes, which comprises the focus of the next chapter.

CHAPTER 5 – COGNITIVE FLEXIBILITY AND PUPILS' OTHER COMPETENCIES IN RWANDA (RQ2)

The preceding chapter examined the measurement of Rwandan learners' cognitive flexibility and the different factors associated with its development. The findings revealed that both pupils' class grade and the school they attended significantly predicted their performance on the cognitive flexibility assessments. However, within schools and classrooms the specific processes that may influence and shape children's cognitive flexibility remain unknown, as does its relationship with other more traditional outcomes of formal education. This chapter consequently addresses the latter issue and answers the second research question (RQ2) which considers "How does the cognitive flexibility development of Rwandan public primary school pupils relate to their other cognitive competencies?"

In particular, the study explores associations between learners' cognitive flexibility and their literacy, non-verbal reasoning and wider executive function[37]. Already, numerous inquiries summarised in section 2.2.3 have investigated the mental linkages between children's cognitive flexibility and other executive functions such as working memory and inhibitory control. However, relatively few of these studies have examined the intricacies of learners' development in lower-income contexts like Rwanda (Bellaj et al., 2016; Schulson, 2020). Similarly, Cartwright (2008, 2009, 2012) has highlighted the potential importance of cognitive flexibility for children's early reading and comprehension, as outlined in section 3.6.3. She nevertheless notes the limited research in the area, much of which has focused on the role of cognitive flexibility in fostering emerging literacy rather than the reverse, or indeed treating cognitive flexibility as a valuable outcome in its own right (Engel de Abreu et al., 2014; Wolf & McCoy, 2019).

This chapter therefore builds on the contribution of Chapter 4, which described the measurement of cognitive flexibility in Rwanda for the first time, to examine how it relates to other aspects of pupils' learning and development. To do this, the first section describes the analytical approach used to address RQ2, while the second, third and fourth sections outline the results of different assessments to reliably measure children's non-verbal reasoning, global executive function and literacy respectively, and how cognitive flexibility relates to each of

[37] Numeracy also represents an important learning outcome for primary-aged children in Rwanda and worldwide. However, its assessment was omitted from the present study as discussed in section 8.3 on research limitations.

them. The fifth section explores whether cognitive flexibility may be predicted by pupils' wider learning, while the sixth section discusses the findings and their implications to conclude the chapter.

5.1 Analytical Approach

Figure 4.1 above highlighted the potential relationship between children's cognitive flexibility and the development of their other, wider cognitive competencies. Indeed, the two-way arrow indicates that such relationship may be bi-directional, with cognitive flexibility both influencing and being influenced by these abilities.

Diamond (2014) in particular emphasises the need for cognitive flexibility to undertake more complex activities. She suggests that, together with working memory and inhibitory control, cognitive flexibility is necessary for learners to perform higher-level mental processes like reasoning, planning and problem solving. Such competencies may therefore be construed as being, at least in part, a function of cognitive flexibility, although this theory appears to remain untested in lower-income countries.

For this reason, the study captured data on Rwandan pupils' non-verbal reasoning and global executive function, in addition to their cognitive flexibility. While executive function is not necessarily equivalent with planning and problem solving, it does concern children's ability to work towards a predefined goal as discussed in section 3.6.3. The enumerators also assessed children's emerging reading skills, not least because literacy remains a primary objective and quantifiable learning outcome for basic education in Rwanda and worldwide. Any significant findings could thereby offer valuable insights for how schools might better teach reading, reasoning and problem-solving competencies.

To explore the various relationships, I first conducted correlational analyses between each measure of cognitive flexibility and the combined score, calculated in accordance with section 4.4.1, and learners' performance on the non-verbal reasoning, executive function and literacy assessments. I then ran regressions to examine the extent to which pupils' cognitive flexibility scores predicted their performance on the other competencies. In each case, I controlled for key independent variables, such as learners' class, school and gender, some of which showed statistically significant associations with their cognitive flexibility as described in Chapter 4.

I finally conducted regressions treating the combined cognitive flexibility score as the dependent variable. Noting the prevalence of studies that emphasise the contribution of cognitive flexibility to other learning outcomes, rather than the reverse, I explored the extent to which pupils' non-verbal reasoning, executive function and literacy might predict their ability to switch and shift. Again, I controlled for the different variables identified in Chapter 4 as significantly associated with children's cognitive flexibility.

Throughout the process, certain assumptions regarding the nature and distribution of the data underpinned the use of parametric analyses, such as the linear regressions. These assumptions are described in section 4.1.2 and presume that the data are homoscedastic, free from bias and derived from a normal sampling distribution (Field, 2009). For each competency, I therefore discuss any deviations from these assumptions that might affect the validity of the findings or their interpretation at face value. With the analytical approach now outlined, the following sections examine Rwandan children's performance on the three competency assessments and how they relate to their cognitive flexibility development.

5.2 Non-verbal Reasoning

As described in section 3.6.3, the enumerators measured Rwandan pupils' non-verbal reasoning, also known as fluid intelligence, using the Object-based Pattern Reasoning Assessment (OPRA). Such assessment was developed in Zambia by Zuilkowski et al. (2016) to address concerns around the two-dimensionality of more traditional tests such as the Raven's Progressive Matrices. Capturing data on learners' reasoning skills was important not just as a competence highlighted in the Rwandan curriculum, but also because of its relevance for respondents to abstract salient dimensions in inductive measures of cognitive flexibility such as the Flexible Item Selection Task (FIST) (Jacques & Zelazo, 2001; REB & MINEDUC, 2015). Indeed, differences in children's performance on the OPRA could explain some of the variation between their scores on the FIST and the Dimension Change Card Sort (DCCS), as outlined in section 4.2.5.

5.2.1 OPRA Analysis, Descriptive Statistics and Reliability

For each child, the enumerators recorded which item he or she used to complete a six-object sequence across ten trials. The patterns started with basic AAAAAA and ABABAB arrangements but progressed in difficulty to the final two trials which used wooden tiles painted with geometric shapes. The enumerators' tablets had been programmed with the correct responses in advance to calculate each pupil's proportional score out of ten[38].

Table 5.1 shows the key descriptive statistics for the measure, for all children combined and disaggregated for Primary 1 and 4 pupils. The mean score of .47 compares closely with the results of the study by Zuilkowski et al. (2016) where Zambian 6-year-olds achieved an average of 4.5 correct items out of 10. The standardised *z*-scores reveal that there are no outliers, while learners in Primary 4 performed better than those in Primary 1, with no overlap between their 95 per cent confidence intervals. This difference is corroborated by Figure 5.1 which depicts histograms of the pupils' OPRA scores by cohort. In the left chart, the Primary 1 children's results are largely normally distributed, albeit with a slight positive skew, however, in the right chart there is a more mixed distribution with fewer learners achieving low scores and a higher proportion performing at or near ceiling.

Table 5.1 - Descriptive Statistics for the OPRA Scores

Variable	Mean	Standard Deviation	Possible Range	Actual Range	95% Confidence Interval		*Z*-Score Range
Combined	.47	.24	0-1	0-1	.44	.49	-1.92-2.19
Primary 1	.33	.16	0-1	0-.80	.30	.35	-1.92-1.37
Primary 4	.61	.23	0-1	0-1	.57	.64	-1.92-2.19

Source: Primary data, 2018. Notes: The OPRA score indicates the proportion of correct items selected by a pupil out of the total number of properly arranged sequences.

[38] During administration, there were six occasions where the research assistants improperly set up one or more of the sequences. Where this happened, and the mistake was detected, the enumerator recorded a comment to describe the error. In such instances, I excluded the child's response from the relevant trial and then calculated the proportion of correct responses as the outcome variable for all pupils, using scores from the correctly set up patterns only.

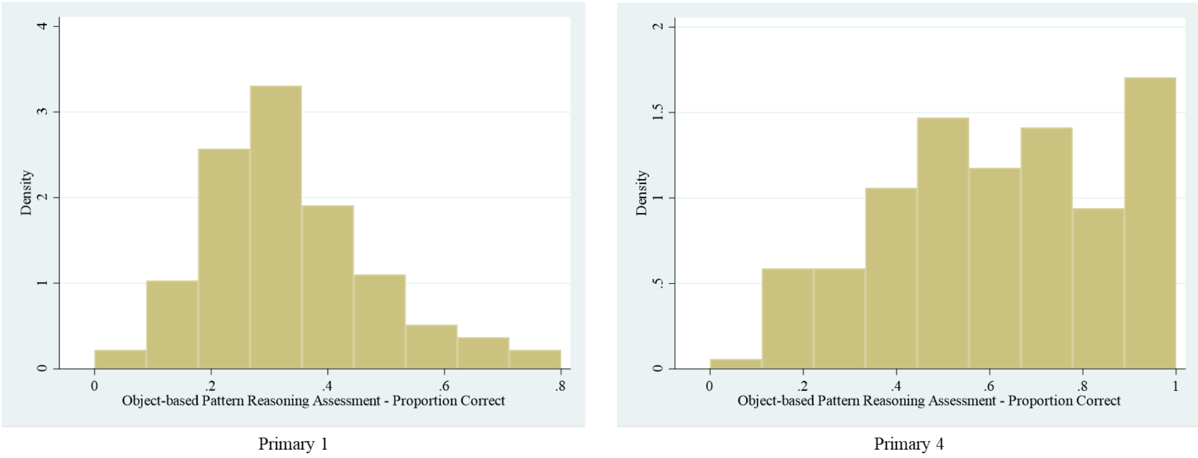


Figure 5.1 - Comparison of Primary 1 and 4 OPRA Scores

Source: Primary data, 2018. Notes: This figure shows comparative histograms representing Primary 1 and 4 pupils' OPRA scores, calculated as the proportion of correct items selected out of the total number of properly arranged sequences.

Regarding reliability, Zuilkowski et al. (2016) reported Cronbach's alphas of .72 and .74 for two national samples undertaken in 2010 and 2012 respectively. The OPRA scores in the current study showed a similar level of overall inter-item consistency, with an alpha of .72 across the two cohorts, above the .70 threshold widely considered as acceptable (Field, 2009). However, *within* the cohorts the reliability of the measure was lower, .71 for Primary 4 learners and just .45 for the Primary 1 pupils. This difference was somewhat surprising since the OPRA was initially developed and validated with younger children, 6-year-olds, in Zambia, but likely reflects the increasing difficulty of items across the task.

In summary, the present study used the same assessment for Primary 1 and 4 pupils to compare their performance, examine differences in their non-verbal reasoning and explore how such variation relates to differences in their cognitive flexibility. The Cronbach's alphas indicate that the OPRA is more reliable for the older cohort of Rwandan children but overall it appears to provide a reasonable measure of pupils' non-verbal reasoning. In which case, the following sections explore the relationship between Rwandan learners' cognitive flexibility and this competency in greater depth.

5.2.2 Correlations between Non-verbal Reasoning and Cognitive Flexibility

As a first step to understand this relationship, I conducted correlation analysis between the main relevant variables. Table 5.2 shows the Pearson's correlation coefficients and reveals statistically significant correlations between pupils' non-verbal reasoning and all measures of cognitive flexibility for the combined Primary 1 and 4 dataset at the 0.10 per cent level. Disaggregating the data by grade further shows a significant association between OPRA scores and FIST performance for the younger children (.25-.30), and with the DCCS and combined cognitive flexibility scores for the older learners (.24).

Table 5.2 - Correlations between OPRA and Cognitive Flexibility Scores

Variable	Combined	Primary 1	Primary 4
Combined Cognitive Flexibility	.50***	.13	.24**
DCCS Ratio (proportion)	.32***	-.04	.24**
FIST Proportion	.49***	.30***	.12
FIST Abstraction	.44***	.29***	.03
FIST Shifting	.49***	.25**	.16

Source: Primary data, 2018. **$p < .01$, ***$p < .001$. Notes: The OPRA score indicates the proportion of correct items selected by a pupil out of the total number of properly arranged sequences. The DCCS Ratio and FIST Proportion variables show a child's proportion of correct matches across the respective tasks, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for these two variables. Further, the FIST Abstraction score represents the proportion of first matches correct across the measure and FIST Shifting denotes the proportion of subsequent correct matches.

Overall, there appears to be a relationship between Rwandan children's cognitive flexibility and their non-verbal reasoning, however, the precise interaction between them is unclear and seems to vary by grade. In light of these complexities, I conducted ordinary least squares regressions to examine whether learners' cognitive flexibility not only correlates with their OPRA scores, but can also predict them as well.

5.2.3 Predicting Non-verbal Reasoning

Table 5.2 revealed differences in correlation patterns between measures of non-verbal reasoning and cognitive flexibility according to children's class grade. In which case, I first ran regressions for the Rwandan learners in Primary 1 and Primary 4 separately, treating their standardised non-verbal reasoning scores as the dependent outcome variable. At the Primary 1 level, pupils' performance on the FIST was correlated with their non-verbal reasoning so I used the proportional FIST score as the main predictor in the first regression, and the combined cognitive flexibility score as the explanatory variable in the second. Neither of the FIST abstraction or shifting variables were included in the regressions, being highly correlated at the

Primary 1 level with the proportional FIST score (.91-.92) and each other (.68), as this would have given rise to problems of multicollinearity.

However, Chapter 4 identified various other factors that showed statistically significant associations with and, in some cases, predicted one or more measures of learners' cognitive flexibility. To capture the unique contribution of pupils' cognitive flexibility to their non-verbal reasoning, I therefore needed to control for these additional variables. For Primary 1 children, these factors included: whether the learner reported drinking anything before school that day; how many meals he or she ate in an average day; how frequently the learner reported eating fish; how many years of pre-primary schooling he or she had attended; and whether the learner had repeated any years of primary education.

In addition to these variables showing *empirical* associations, there were also several factors that related to the design and structure of the study. These were controlled through the administration of the research, for example in the stratified sampling strategy, and included pupils' ages, the school they attended and the specific enumerator that assessed them. In the case of the Primary 1 regressions, each of these variables also showed statistically significant relationships with learners' cognitive flexibility and so needed to be controlled for in the non-verbal reasoning regressions.

By contrast, pupils' gender was not reflected in the sampling approach. This was because, as indicated in section 3.5.4, there is little if any international evidence to suggest material differences in children's cognitive flexibility according to their gender (Bellaj et al., 2016; Willoughby et al., 2019). Indeed, findings from this study among learners in both Primary 1 and 4 corroborated that position, as shown in Tables 4.9 and 4.11, however, such equivalence between boys and girls cannot be assumed for other learning outcomes and so gender was also included in the regressions.

Table 5.3 below sets out the key statistics for the Primary 1 regressions[39]. The first model which uses the FIST proportional score shows a higher level of fit, the R^2 value indicating that

[39] In the interests of concision and parsimony, the regression tables in Chapter 5 report coefficients, standard errors and significance only, but do not include the standardised coefficients or confidence intervals provided in Chapter 4. Similarly, numerous tables in Chapter 5 combine multiple stepwise regressions, again for reasons of brevity and parsimony.

it explains 20 per cent of the variance in learners' non-verbal reasoning, or 12 per cent when adjusted for the number of variables (the adjusted R^2). Indeed, Primary 1 pupils' performance on the FIST significantly predicted their non-verbal reasoning at the 1 per cent level, with an additional standard deviation on the FIST accounting for an extra 28 per cent of a standard deviation on the OPRA score, holding other variables constant, $b = 0.28$, $p < .01$. By contrast, the combined cognitive flexibility score did not significantly predict children's non-verbal reasoning in the second regression, however, whether or not learners reported repeating any years of primary education predicted their OPRA scores at the 1 per cent level in both models. Specifically, pupils who claimed to have repeated at least 1 year of primary schooling achieved 35 per cent of a standard deviation higher on the non-verbal reasoning score than their peers, after controlling for other factors, $b = 0.35$, $p < .01$.

I adopted a similar approach for the Primary 4 regressions. Once again, the standardised *z*-scores for the OPRA comprised the dependent outcome variable, and I included pupils' performance on the DCCS and their combined cognitive flexibility scores as the main predictors in each model, being significantly correlated with Primary 4 learners' non-verbal reasoning as shown in Table 5.2. Following the approach for the Primary 1 regressions, I also controlled for design-based factors including learners' school, age and gender, and variables identified in Chapter 4 as showing statistically significant associations with their cognitive flexibility. These comprised: pupils' family structure and household environment; whether they spoke multiple languages at home; how many family members they saw reading and how often; and the type of house children reported living in.

The results of the Primary 4 regressions are shown in Table 5.4. The models display reasonable levels of fit, accounting for up to 23 per cent of the variance in pupils' non-verbal reasoning scores (R^2), or 13 per cent when adjusted for the number of explanatory variables (the adjusted R^2). Both regressions also show that learners' cognitive flexibility significantly predicted their non-verbal reasoning at the 5 per cent level or below. In the first model, for every standard deviation on the DCCS *z*-score, pupils achieved 23 per cent of a standard deviation higher on the OPRA *z*-score, holding other factors constant, $b = 0.23$, $p = .01$. Likewise, in the second model, an additional standard deviation on the combined cognitive flexibility score translates into an extra 38 per cent of a standard deviation on the OPRA, after controlling for other variables, $b = 0.38$, $p < .01$. Beyond cognitive flexibility, both regressions reveal that children's home environment also appeared to predict their non-verbal reasoning. Pupils who reported living in stressful families scored 91 per cent of a standard deviation *lower* on the OPRA, holding other factors constant, $b = -0.91$, $p < .01$.

Table 5.3 - Regression Coefficients (Standard Errors) for Primary 1 Pupils' Non-verbal Reasoning

	(1)	(2)
FIST Proportion	0.28 (0.08)**	-
Combined Cognitive Flexibility	-	0.14 (0.09)
Gender	-0.07 (0.11)	-0.09 (0.11)
Pupil age	-0.04 (0.12)	-0.04 (0.13)
Drank before school	-0.03 (0.12)	-0.05 (0.13)
Meals per day	0.02 (0.09)	0.03 (0.09)
Frequency of eating fish	0.00 (0.04)	0.00 (0.04)
Years of pre-primary	0.04 (0.03)	0.05 (0.04)
Repeated any primary	0.35 (0.12)**	0.33 (0.12) **
School		
- School 2	-0.21 (0.19)	-0.27 (0.20)
- School 3	-0.39 (0.21)	-0.49 (0.22)*
- School 4	-0.15 (0.16)	-0.19 (0.16)
Enumerator		
- Enumerator 2	-0.15 (0.20)	-0.23 (0.21)
- Enumerator 3	-0.13 (0.17)	-0.16 (0.17)
- Enumerator 4	-0.09 (0.23)	-0.21 (0.24)
Constant	0.05 (0.93)	0.01 (0.98)
R-squared	.20	.14
Adjusted R-squared	.12	.05
Observations	151	151

Source: Primary data, 2018. $^{*}p < .05$, $^{**}p < .01$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Primary 1 pupils' non-verbal reasoning, based on their proportion of correct items selected in the OPRA task. The FIST Proportion variable show a child's proportion of correct matches on the FIST, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for the FIST and the DCCS measures.

Table 5.4 - Regression Coefficients (Standard Errors) for Primary 4 Pupils' Non-verbal Reasoning

	(1)	(2)
DCCS Ratio (proportion)	0.23 (0.09)*	-
Combined Cognitive Flexibility	-	0.38 (0.13)**
Gender	-0.27 (0.16)	-0.27 (0.16)
Pupil age	0.11 (0.16)	0.07 (0.16)
Family structure		
- Non-relative guardian(s)	0.53 (0.95)	0.43 (0.94)
- Non-parent family guardian(s)	-0.19 (0.33)	-0.21 (0.33)
- Single parent family	0.18 (0.18)	0.17 (0.18)
Family environment (stress)	-0.91 (0.26)**	-0.91 (0.26)**
Multilingual household	0.06 (0.06)	0.06 (0.06)
Frequency of family reading	0.07 (0.06)	0.08 (0.06)
Number of family readers	-0.28 (0.23)	-0.25 (0.23)
House type		
- Basic house	0.35 (0.24)	0.33 (0.24)
- Large house	-0.01 (0.17)	-0.01 (0.17)
School		
- School 2	0.14 (0.26)	0.19 (0.26)
- School 3	0.14 (0.24)	0.30 (0.25)
- School 4	0.06 (0.24)	0.23 (0.25)
Enumerator		
- Enumerator 2	-0.32 (0.29)	-0.28 (0.29)
- Enumerator 3	-0.31 (0.23)	-0.21 (0.23)
- Enumerator 4	0.06 (0.29)	0.19 (0.29)
Constant	-0.53 (1.74)	-0.43 (1.72)
R-squared	.22	.23
Adjusted R-squared	.11	.13
Observations	149	149

Source: Primary data, 2018. $*p < .05$, $**p < .01$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Primary 4 pupils' non-verbal reasoning, based on their proportion of correct items selected in the OPRA task. The DCCS Ratio (Proportion) variable show a child's proportion of correct matches on the DCCS, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for the DCCS and the FIST measures.

Finally, I combined the data for all Primary 1 and 4 pupils and ran stepwise regressions to explore the extent to which learners' cognitive flexibility predicted their non-verbal reasoning, conditional on the educational and environmental factors that themselves show a statistically significant relationship with cognitive flexibility. For the first model, I conducted a simple regression using children's combined cognitive flexibility scores as the sole explanatory variable. In the second, I controlled for pupils' class grade and in the third regression I included the design-based variables and other factors that showed significant associations with one or both measures of cognitive flexibility at the Primary 1 or 4 levels. Pupils' age was nevertheless omitted, showing high collinearity with their class grade, as discussed in section 4.4.3. In the final regression, I then replaced the combined cognitive flexibility variable with the separate DCCS and FIST scores, again controlling for significant background and design-based factors, to explore whether one measure better predicted Rwandan learners' non-verbal reasoning than the other.

Table 5.5 shows the results of the stepwise regressions. Overall, the models show a good level of fit and explain up to 41 per cent of performance variance on the OPRA, or 36 percent when factoring in the number of variables (adjusted R^2). As with the measures for cognitive flexibility, pupils' class grade emerged as the most significant predictor of their non-verbal reasoning, with learners in Primary 4 scoring between 73 and 89 per cent of a standard deviation higher than those in Primary 1, holding other factors constant.

In each model, children's cognitive flexibility also significantly predicted their non-verbal reasoning at the 1 per cent level or below. Results for the second and third regressions show that one standard deviation on the combined cognitive flexibility score translates into an additional 25 per cent of a standard deviation on the OPRA, after controlling for other factors, $b = 0.25$, $p < .01$. The fourth model further reveals that between the two measures of cognitive flexibility, the FIST is most strongly associated with learners' non-verbal reasoning. Pupils' performance on the DCCS was not statistically significant, but for each standard deviation on the FIST, Rwandan children achieved an extra 20 per cent of a standard deviation on the OPRA, holding other factors constant, $b = 0.20$, $p < .01$.

Table 5.5 - Regression Coefficients (Standard Errors) for Rwandan Pupils' Non-verbal Reasoning

	(1)	(2)	(3)	(4)
Combined Cognitive Flexibility	0.61 (0.06)***	0.25 (0.07)**	0.25 (0.08)**	-
DCCS Ratio (proportion)	-	-	-	0.07 (0.06)
FIST Proportion	-	-	-	0.20 (0.07)**
Gender	-	-	-0.15 (0.10)	-0.15 (0.10)
Class grade	-	0.89 (0.12)***	0.79 (0.14)***	0.73 (0.14)***
Family structure				
- Non-relative guardian(s)	-	-	-0.25 (0.83)	-0.36 (0.84)
- Non-parent family guardian(s)	-	-	-0.02 (0.22)	-0.02 (0.22)
- Single parent family	-	-	0.08 (0.11)	0.09 (0.11)
Drank before school	-	-	0.03 (0.11)	0.04 (0.11)
Meals per day	-	-	-0.10 (0.08)	-0.10 (0.08)
Frequency of eating fish	-	-	0.01 (0.04)	0.01 (0.04)
Family environment (stress)	-	-	-0.39 (0.13)**	-0.38 (0.13)**
Multilingual household	-	-	0.01 (0.04)	0.02 (0.04)
Frequency of family reading	-	-	0.05 (0.04)	0.05 (0.04)
Number of family readers	-	-	-0.20 (0.18)	-0.18 (0.18)
House type				
- Basic house	-	-	0.09 (0.16)	0.09 (0.16)
- Large house	-	-	-0.10 (0.11)	-0.10 (0.11)
Years of pre-primary	-	-	0.02 (0.03)	0.02 (0.03)
Repeated any primary	-	-	0.11 (0.10)	0.11 (0.10)
School				
- School 2	-	-	-0.06 (0.17)	-0.04 (0.17)
- School 3	-	-	-0.17 (0.17)	-0.12 (0.17)
- School 4	-	-	-0.02 (0.15)	0.02 (0.15)
Enumerator				
- Enumerator 2	-	-	-0.24 (0.18)	-0.20 (0.18)
- Enumerator 3	-	-	-0.24 (0.15)	-0.21 (0.15)
- Enumerator 4	-	-	0.05 (0.19)	0.11 (0.20)
Constant	0.00 (0.05)	-0.44 (0.08)***	-0.02 (0.31)	-0.05 (0.31)
R-squared	.25	.36	.41	.41
Adjusted R-squared	.25	.36	.36	.36
Observations	306	306	294	294

Source: Primary data, 2018. $^{**}p < .01$, $^{***}p < .001$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Rwandan pupils' non-verbal reasoning, based on their proportion of correct items selected in the OPRA task. The FIST Proportion and DCCS Ratio (Proportion) variables show a child's proportion of correct matches on each task, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for both measures.

In addition to cognitive flexibility, the regressions show that learners' family environment also significantly predicted their non-verbal reasoning. Specifically, pupils who reported living in stressful households, rather than nurturing or affectionate ones, scored up to 39 per cent less on the OPRA than their peers, after controlling for other factors.

To summarise, the regressions reveal a consistent and positive relationship between Rwandan learners' non-verbal reasoning and their cognitive flexibility. Such relationship remains significant even after controlling for different factors associated with children's cognitive flexibility development. Among the older pupils, 10- and 11-year-olds in Primary 4, performance on the OPRA appears more strongly correlated with the DCCS, but overall the FIST emerges as a more significant predictor of learners' non-verbal reasoning.

Beyond cognitive flexibility, three further variables also appeared to significantly predict children's non-verbal reasoning. First, those 7- and 8-year-olds who claimed to have repeated 1 or more years of primary education scored up to 35 per cent of a standard deviation better on the OPRA than their contemporaries, holding other factors constant. By contrast, learners in Primary 4 who reported living in stressed rather than nurturing families showed significantly worse non-verbal reasoning, and this association remained significant even after combining the two cohorts of Primary 1 and 4 children together. Finally, and similar to the findings of Chapter 4, pupils' class grade emerged as the strongest predictor of their performance on the OPRA, although it remains unknown how much this relates to their greater age and maturity, and how much depends on the contribution of formal education.

5.3 Global Executive Function

In addition to non-verbal reasoning, the research team used the Tower of Hanoi to assess Rwandan pupils' global executive function. As discussed in section 3.6.3, the exact construct measured by the task is contested but at the very least it gauges children's ability to orient themselves towards the achievement of a predefined goal and thereby provide an indication of their overall executive function.

Sections 2.2.1 and 2.2.3 above outlined the relationship between learners' cognitive flexibility and their broader executive function. On the one hand, cognitive flexibility appears to rely and draw on other executive functions, such as working memory and inhibitory control, to switch mental sets or deliberately see something from a different perspective (Diamond, 2016). On the other hand, cognitive flexibility arguably completes the trio of mental processes widely considered as comprising learners' core executive functions (Diamond, 2006, 2014; Miyake et al., 2000). As such, there should be a close relationship between children's cognitive flexibility and their overall executive function, and a study by Bull et al. (2004) found that learners' shifting accounted for 20 per cent of their performance on the Tower of Hanoi.

5.3.1 Tower of Hanoi Analysis, Descriptive Statistics and Reliability

Section 3.6.3 and Appendix 6 describe the administration of the Tower of Hanoi with the Rwandan pupils in detail. In summary, the task started with a simple two-disk practice followed by a maximum of six three-disk rounds that progressed in difficulty. High performers were then invited to undertake a final four-disk round. Learners were scored based on their ability to complete the task using the minimum number of moves, within the assigned time and without any rule violations. Appendix 7 sets out the full scoring structure, which follows the approach taken by Bull et al. (2004) to allocate points depending on the difficulty of the round and how many minimum moves are required.

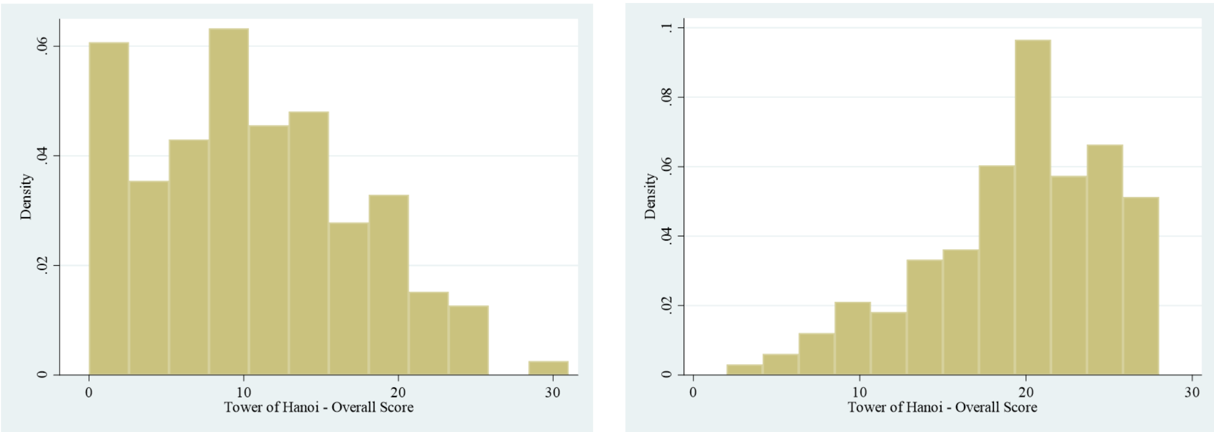
Table 5.6 sets out the descriptive statistics for pupils in Primary 1, Primary 4 and across both cohorts. The overall mean of 14.99 points out of a maximum of 35, or 42.83 per cent, accords with the results of the study by Bull et al. (2004) where 118 younger children between the ages of 3 and 6 achieved an average of 43.44 per cent or around 12 out of a total possible of 27 points. Learners in Primary 4 scored significantly higher than those in Primary 1, as evidenced by the lack of overlap between their 95 per cent confidence intervals, however, a Primary 1 girl achieved the best score across the two class groups with a total of 31 points.

Regarding distribution, the *z*-score ranges indicate that there are no outliers that could give rise to significant bias. The standard deviations for each cohort and combined are also lower than that reported in the study by Bull et al. (2004), being 7.70. Figure 5.2 further shows histograms comparing the Primary 1 and 4 pupils' performance. Neither chart shows a clear normal distribution, however, the slight positive skew for the Primary 1 results and small negative skew for the Primary 4 scores corroborate the differences between the two groups.

Table 5.6 - Descriptive Statistics for the Tower of Hanoi

Variable	Mean	Standard Deviation	Possible Range	Actual Range	95% Confidence Interval		*Z*-Score Range
Combined	14.99	7.54	0-35	0-31	14.14	15.83	-1.99-2.13
Primary 1	10.62	6.71	0-35	0-31	9.55	11.69	-1.99-2.13
Primary 4	19.35	5.52	0-35	2-28	18.47	20.23	-1.72-1.73

Source: Primary data, 2018. Notes: The Tower of Hanoi aggregate score indicates pupils' performance over a maximum of seven trials on the task. For example, learners scored five points if they completed the five-move trial within 1 minute using just five moves, or 2.5 points if they used a greater number of moves. One point was deducted for any illegal move or rule violation.



Primary 1 Primary 4

Figure 5.2 - Comparison of Primary 1 and 4 Tower of Hanoi Scores

Source: Primary data, 2018. Notes: This figure shows comparative histograms representing Primary 1 and 4 pupils' aggregate scores on the Tower of Hanoi, calculated based on the number of moves used to complete each trial within the allocated time and adjusted for any illegal moves or rule violations.

In terms of reliability, published studies using the Tower of Hanoi typically report on its test-retest reliability and the stability of scores over time, rather than its inter-item consistency (Ahonniska et al., 2000; Bull et al., 2004). This may be because, depending on how the task is organised, the trials become progressively more difficult and so participants are more likely to achieve higher scores in the earlier rounds. Even where the test-retest reliability for the Tower of Hanoi is calculated, the coefficients often tend to be low. Bishop, Aamodt-Leeper, Creswell, McGurk and Skuse (2001), for example, found a test-retest reliability of .53 for British children undertaking the task over a period of 30 to 40 days. More broadly, repeated measures of executive function tasks with the same participants generally display poor internal validity and test-retest reliability because such mental processes are most engaged for individuals when the activities are new (Miyake et al., 2000; Rabbitt, 1997).

Notwithstanding these limitations, and recognising that children's responses were collected at one time point only, I calculated Cronbach's alpha as a measure of reliability for the Tower of Hanoi responses. For the combined dataset, the inter-item consistency was .69, just below the .70 threshold generally considered to be acceptable (Field, 2009). However, within the cohorts the alphas were lower, .66 for the Primary 1 learners and .43 for the Primary 4 pupils. Similar to the coefficients for non-verbal reasoning, this difference in reliability likely results from both increasingly difficult items and the use of 'stop' rules to control progression to later stages of the assessment.

In summary, the Rwandan pupils undertook the same Tower of Hanoi task across the Primary 1 and 4 cohorts, not least to explore how any differences in performance might also relate to their cognitive flexibility. Reliability analyses raised some queries regarding its use at the Primary 4 level, however, overall, the tool appears to offer a reasonable assessment of learners' global executive function.

5.3.2 Correlations between Global Executive Function and Cognitive Flexibility

To examine the relationship between Rwandan learners' cognitive flexibility and their executive function, I conducted correlation analysis following the approach outlined in section 5.2.2. Table 5.7 below summarises Pearson's correlation coefficients between pupils' Tower of Hanoi scores and each measure of cognitive flexibility, together with their statistical significance. Values are provided for the combined cohorts, as well as disaggregated for Primary 1 and 4.

As with the non-verbal reasoning scores, all correlations are positive and statistically significant at the 0.10 per cent level when the two cohorts are combined. However, once pupils' class grade is taken into account, their switching scores on the DCCS cease to be significant for either Primary 1 or Primary 4. Meanwhile, learners' performance on the FIST is statistically significant for Primary 1 pupils, but not those in Primary 4. Finally, for all groups, Primary 1, Primary 4 and the combined cohorts, the correlation with Tower of Hanoi scores is higher for the shifting component of the FIST than the abstraction measure, but the differences between these correlations are not statistically significant.

Table 5.7 - Summary of Correlations between Tower of Hanoi and Cognitive Flexibility Scores

Variable	Combined	Primary 1	Primary 4
Combined Cognitive Flexibility	.49***	.23**	.10
DCCS Ratio (proportion)	.29***	.05	.09
FIST Proportion	.50***	.35***	.06
FIST Abstraction	.46***	.28***	.03
FIST Shifting	.49***	.36***	.07

Source: Primary data, 2018. $**p < .01$, $***p < .001$. Notes: The Tower of Hanoi aggregate score indicates pupils' performance over a maximum of seven trials on the task. The DCCS Ratio and FIST Proportion variables show a child's proportion of correct matches across the respective tasks, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for these two variables. Further, the FIST Abstraction score represents the proportion of first matches correct across the measure and FIST Shifting denotes the proportion of correct subsequent matches.

5.3.3 Predicting Global Executive Function

To examine the relationships further, I conducted ordinary least squares regressions to explore the extent to which measures of cognitive flexibility not just correlate with Rwandan pupils' executive function, but also predict it as well.

First, I ran two multivariate regressions using Primary 1 learners' standardised scores on the Tower of Hanoi as the dependent variable and their FIST performance and combined cognitive flexibility score as the main explanatory variables. Only the overall FIST measure was included in the first regression to avoid issues of multicollinearity, and the DCCS scores were omitted on account of being uncorrelated with pupils' executive function, as shown in Table 5.7. I nevertheless controlled for numerous factors that showed significant associations with Primary 1 children's cognitive flexibility as listed in section 5.2.3.

Table 5.8 below shows the key statistics for the two Primary 1 regressions. Similar to the results for non-verbal reasoning, the first model using the FIST proportional score displays a better level of fit, explaining 24 per cent of variance in learners' Tower of Hanoi scores, or 16 per cent once adjusted for the number of variables. Both pupils' shifting as measured by the FIST and their combined cognitive flexibility score significantly predicted their global executive function at the 1 per cent level or below, and regarding the former, one standard deviation on the FIST accounted for an increase of 43 per cent of a standard deviation on the Tower of Hanoi, holding other factors constant, $b = 0.43$, $p < .01$.

Several background variables also significantly predicted children's global executive function in one or both models. First, learners who reported drinking something before coming to school on the day of the assessment scored up to 40 per cent of a standard deviation worse on the Tower of Hanoi than their peers, after controlling for other factors, $b = -0.40$, $p = .01$. Although this contrasts with wider literature on the relationship between executive function and poverty, it matches the finding in section 4.4.1 whereby Primary 1 pupils who drank before school also performed worse on the DCCS measure of cognitive flexibility.

Second, children's pre-primary experiences and the enumerator that tested them also significantly predicted their global executive function. Regarding the former, each year of pre-primary education that a learner reported attending translated to a 9 per cent of a standard deviation increase on the Tower of Hanoi, holding other factors constant, $b = 0.09$, $p = .04$. By contrast, pupils undertaking the assessment with a particular member of the research team scored 67 per cent of a standard deviation less on the executive function task after controlling for other variables, $b = -0.67$, $p = .01$.

At the Primary 4 level, Table 5.7 showed that there were no significant correlations between pupils' performance on the Tower of Hanoi and any measure of cognitive flexibility. This lack of association was surprising and conflicts with evidence in the prevailing literature but might be explained, at least in part, by the lower reliability of the Tower of Hanoi as a measure of executive function for the older Rwandan learners. As such, I did not conduct regressions using the Primary 4 data alone, but rather combined the Primary 1 and Primary 4 scores to run cross-cohort multivariate regressions.

Table 5.8 - Regression Coefficients (Standard Errors) for Primary 1 Pupils' Executive Function

	(1)	(2)
FIST Proportion	0.43 (0.10)***	-
Combined Cognitive Flexibility	-	0.38 (0.12)**
Gender	0.09 (0.14)	0.07 (0.15)
Pupil age	0.20 (0.16)	0.17 (0.16)
Drank before school	-0.40 (0.16)*	-0.39 (0.16)*
Meals per day	0.03 (0.11)	0.05 (0.12)
Frequency of eating fish	0.03 (0.06)	0.04 (0.06)
Years of pre-primary	0.07 (0.04)	0.09 (0.04)*
Repeated any primary	-0.12 (0.15)	-0.16 (0.16)
School		
- School 2	0.29 (0.25)	0.19 (0.26)
- School 3	-0.09 (0.27)	-0.23 (0.28)
- School 4	0.28 (0.20)	0.24 (0.21)
Enumerator		
- Enumerator 2	-0.50 (0.26)	-0.67 (0.26)*
- Enumerator 3	0.09 (0.21)	0.04 (0.22)
- Enumerator 4	-0.19 (0.30)	-0.36 (0.30)
Constant	-1.75 (1.20)	-1.54 (1.25)
R-squared	.24	.20
Adjusted R-squared	.16	.11
Observations	151	151

Source: Primary data, 2018. $*p < .05$, $**p < .01$, $***p < .001$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Primary 1 pupils' global executive function, based on their performance on the Tower of Hanoi over a maximum of seven trials on the task. The FIST Proportion variable show a child's proportion of correct matches on the FIST, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for the FIST and the DCCS measures.

In particular, I followed the same stepwise approach used for non-verbal reasoning and described in section 5.2.3 above. This entailed an initial regression predicting executive function based on children's combined cognitive flexibility scores only, before controlling for their class grade and other factors associated with cognitive flexibility development. In the final model, I then replaced the combined score with the separate DCCS and FIST variables to test the correlations in Table 5.7 and whether the FIST indeed provides a better prediction of learners' executive function.

The results of the regressions are shown in Table 5.9 below. Generally, the models show a good level of fit, explaining up to 43 per cent of the variance in pupils' executive function, or 37 per cent when the number of variables is taken into account (the adjusted R^2). In each case, children's cognitive flexibility significantly predicted their Tower of Hanoi performance, with one standard deviation on the combined measure accounting for 25 per cent of a standard deviation on the executive function score, even after controlling for various factors that themselves show significant associations with learners' cognitive flexibility, $b = 0.25$, $p < .01$. As with non-verbal reasoning, the results of the fourth regression also show that pupils' FIST scores significantly predicted their Tower of Hanoi performance while switching abilities measured by the DCCS appear unrelated to children's global executive function.

In terms of other factors, four school- and design-based variables also predicted learners' scores on the Tower of Hanoi. Most significantly, and similar to the findings for cognitive flexibility and non-verbal reasoning, pupils' class grade was the strongest predictor of their executive function performance. Holding other factors constant, Primary 4 children achieved at least 81 per cent of a standard deviation higher on the Tower of Hanoi than those in Primary 1, $b = 0.81$, $p < .01$. Likewise, learners' pre-primary education predicted their executive function performance at the 5 per cent level. Specifically, each year of pre-primary schooling that pupils reported translated to an increase of at least 7 per cent of a standard deviation on their Tower of Hanoi score, after controlling for other factors, $b = 0.07$, $p = .02$.

Table 5.9 - Regression Coefficients (Standard Errors) for Rwandan Pupils' Executive Function

	(1)	(2)	(3)	(4)
Combined Cognitive Flexibility	0.59 (0.06)***	0.23 (0.07)**	0.25 (0.08)**	-
DCCS Ratio (proportion)	-	-	-	0.06 (0.06)
FIST Proportion	-	-	-	0.21 (0.07)**
Gender	-	-	-0.03 (0.10)	-0.02 (0.10)
Class grade	-	0.92 (0.12)***	0.87 (0.14)***	0.81 (0.14)***
Family structure				
- Non-relative guardian(s)	-	-	0.61 (0.83)	0.48 (0.83)
- Non-parent family guardian(s)	-	-	-0.06 (0.22)	-0.06 (0.22)
- Single parent family	-	-	-0.09 (0.11)	-0.07 (0.11)
Drank before school	-	-	-0.12 (0.11)	-0.11 (0.11)
Meals per day	-	-	-0.08 (0.08)	-0.08 (0.08)
Frequency of eating fish	-	-	0.01 (0.04)	0.01 (0.04)
Family environment (stress)	-	-	-0.20 (0.13)	-0.19 (0.13)
Multilingual household	-	-	-0.08 (0.04)	-0.07 (0.04)
Frequency of family reading	-	-	0.08 (0.04)	0.08 (0.04)
Number of family readers	-	-	-0.36 (0.18)	-0.34 (0.18)
House type				
- Basic house	-	-	-0.02 (0.16)	-0.03 (0.15)
- Large house	-	-	-0.07 (0.11)	-0.08 (0.11)
Years of pre-primary	-	-	0.08 (0.03)*	0.07 (0.03)*
Repeated any primary	-	-	-0.09 (0.10)	-0.09 (0.10)
School				
- School 2	-	-	0.20 (0.16)	0.22 (0.16)
- School 3	-	-	-0.18 (0.17)	-0.13 (0.17)
- School 4	-	-	0.36 (0.15)	0.40 (0.15)**
Enumerator				
- Enumerator 2	-	-	-0.42 (0.18)*	-0.38 (0.18)*
- Enumerator 3	-	-	0.06 (0.15)	0.09 (0.15)
- Enumerator 4	-	-	-0.26 (0.19)	-0.20 (0.19)
Constant	0.00 (0.05)	-0.46 (0.08)***	-0.13 (0.31)	-0.17 (0.31)
R-squared	.24	.36	.42	.43
Adjusted R-squared	.23	.35	.37	.37
Observations	306	306	294	294

Source: Primary data, 2018. *$p < .05$, **$p < .01$, ***$p < .001$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Rwandan pupils' global executive function, based on their performance on the Tower of Hanoi over a maximum of seven trials on the task. The FIST Proportion and DCCS Ratio (Proportion) variables show a child's proportion of correct matches on each task, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for both measures.

Similarly, two design-based factors predicted children's executive function. First, Rwandan pupils assessed by one enumerator scored at least 38 per cent of a standard deviation lower than those tested by another, after controlling for other variables, $b = -0.38$, $p = .04$. Second, in the fourth regression, the school learners attended was significant at the 1 per cent level, and children in School 4 achieved 40 per cent of a standard deviation higher than those in School 1, holding other factors constant, $b = 0.40$, $p = .01$. This was in direct contrast to the finding regarding Primary 4 pupils' cognitive flexibility, whereby pupils in School 1 performed significantly better than those in School 4.

In summary, the regressions show a significant and positive association between learners' cognitive flexibility and their global executive function, as measured by the Tower of Hanoi. Between the assessments, the FIST once again displays a stronger relationship with children's development than the DCCS, predicting 21 per cent of executive function variance and corroborating the results of the study by Bull et al. (2004). Nevertheless, pupils' class grade emerges as the most significant predictor of their performance on the Tower of Hanoi, although these findings must be interpreted in light of questions around the reliability of the measure for use with older Rwandan learners (Miyake et al., 2000).

5.4 Reading and Literacy

In the final assessment, the enumerators tested Rwandan pupils' basic literacy and reading skills. As summarised in sections 2.2.5 and 3.6.3, international research has already highlighted the key role that cognitive flexibility appears to play in various aspects of children's literacy acquisition, not least their letter-sound decoding, word-reading proficiency and wider comprehension (Cartwright, 2008, 2009, 2012; Meltzer & Bagnato, 2010; Mills et al., 2019). However, such relationship appears to remain unknown and untested in Rwanda and other similar African contexts.

Indeed, data on learners' literacy and how it relates to their cognitive flexibility were important for the study to capture because, unlike executive function and non-verbal reasoning, Rwandan teachers provide direct and explicit instruction on how to build and improve their pupils' reading skills. Like most if not all education systems worldwide, the Rwandan curriculum identifies literacy as a core learning outcome and a major indicator of students' attainment and success (MINEDUC, 2015). By understanding its relationship with cognitive flexibility, the study might thereby offer useful insight on how both competencies are currently being nurtured, and could be enhanced in the future.

5.4.1 Literacy Analysis, Descriptive Statistics and Reliability

As described in section 3.6.3, the literacy measures drew on two instruments already established and validated in the Rwandan context, the Oral Reading Fluency Assessment of Rwandan Schools (FARS) and the Early Grade Reading Assessment (EGRA). Specifically, children were tested over a maximum of four rounds on the number of letters they could correctly sound and the words they could accurately read in Kinyarwanda, their oral reading fluency, during the course of a minute[40]. In the final two tasks, pupils were also asked comprehension questions to assess how well they had understood the stories they had just read[41]. In most cases, these were recall or 'locator' questions, such as the name of a character or place, which did not require the children to exercise any inference or interpretation (Moulton, 2016). However, the pupils were also asked at least one inference question, which drew on their cognitive flexibility to link the relevant narrative to their own knowledge or wider world experience (Cartwright, 2009; RTI International, 2016).

Preliminary analyses revealed numerous outliers that could bias the data in the third task of the assessment. One pupil scored more than three standard deviations above the reading fluency mean, while seven children performed more than three standard deviations below the mean on the comprehension exercise. In each case, I addressed the extreme values by winsorising the relevant data points, replacing the outliers with the next highest or lowest values that were not outliers, that is the respective means plus or minus three standard deviations (Field, 2009).

[40] Unlike previous measures in the study, the enumerators used paper scoresheets to record the learners' responses and whether they read each letter or word correctly. Practice during the programming phase had raised concerns about the speed of the tablet software and whether it would be quick enough to keep pace with the faster children. Using the tablets also increased the risk of enumerator error if they entered any responses inaccurately and needed to go back to make a correction. In which case, the research team marked each pupil's responses for individual letters and words on the scoresheet and then entered the total for each round into the tablets once the learner had returned to class. Where pupils completed more than one reading exercise, their fluency was calculated as the average across the tasks that they were able to perform. Correlations between such tasks were statistically significant ($p < .01$) and high, ranging from .82 to .88.

[41] Ordinarily, children undertaking the EGRA or FARS are only asked comprehension questions pertaining to the sentences of each passage that they have actually read. This avoids slower readers being penalised for not knowing the answers to questions on the later sections of a story. In the current study, this was not feasible given the use of paper scoresheets, but I subsequently adjusted the maximum number of possible questions so that pupils were scored on their comprehension of the sentences they had read only.

Table 5.10 sets out a summary of the combined statistics for the literacy tasks, as well as Primary 1 and 4 learners' oral reading fluency and the latter's comprehension scores. Appendix 13 also provides the full results for each measure disaggregated by class grade and gender. Together, they reveal several findings of particular note, not least the wide difference in performance between pupils in Primary 1 and Primary 4.

Table 5.10 - Summary of Rwandan Pupils' Performance on Literacy Assessments

Respondents	Obs	Mean	Standard Deviation	Mean – Girls	Mean – Boys	Score Range	95% Confidence Interval		*Z*-Score Range
Letter-Sound Activity – letters correctly sounded per minute (EGRA)									
Combined	306	32.83	31.79	31.36	34.06	0-105.26	29.26	36.41	-1.03-2.28
Familiar Word Fluency Activity – words correctly read per minute (EGRA)									
Combined	306	19.85	21.43	18.55	20.93	0-73.85	17.44	22.26	-0.93-2.52
Reading Comprehension Activities A – words correctly read per minute (FARS)									
Combined	157	43.93	17.56	43.88	43.96	1.00-96.51	41.16	46.69	-2.44-2.99
Reading Comprehension Activities A – proportion of comprehension questions correctly answered (FARS)									
Primary 4	151	0.92	0.14	0.91	0.94	0.45-1.00	0.90	0.95	-2.99-0.55
Reading Comprehension Activities B – words correctly read per minute (EGRA)									
Combined	153	41.08	15.66	39.92	41.91	2.00-82.86	38.58	43.58	-2.50-2.67
Reading Comprehension Activities B – proportion of comprehension questions correctly answered (EGRA)									
Primary 4	147	0.63	0.31	0.65	0.62	0-1.00	0.58	0.68	-2.04-1.20
Overall Oral Reading Fluency – words correctly read per minute									
Combined	306	21.06	23.05	19.50	22.36	0-84.40	18.47	23.65	-0.91-2.75
Primary 1	153	0.51	2.42	0.85	0.18	0-22.00	0.12	0.90	-0.91-0.04
Primary 4	153	41.61	14.49	41.35	41.80	0-84.40	39.30	43.93	-0.91-2.75
Overall Reading Comprehension – proportion of questions answered correctly									
Primary 4	151	0.78	0.18	0.78	0.78	0.23-1.00	0.75	0.81	-2.98-1.20

Source: Primary data, 2018. Notes: The Letter-Sound Activity indicates the number of letters that pupils could accurately name, while the Familiar Word Fluency Activity shows the number of Kinyarwanda words read correct, both within a minute. The Reading Comprehension Activities combine the number of words read correctly in 1 minute, as well as the proportion of comprehension questions answered successfully. The Oral Reading Fluency score takes an average of words read accurately per minute and the Reading Comprehension score takes a mean of the proportion of correct answers across the two tasks.

Specifically, most of the Primary 1 children could not identify more than a few letters and were therefore unable to read any whole words. From a sub-sample of 153 learners, only 15 Primary 1 pupils progressed to the second exercise or beyond. This was to be expected, not least because many of the children were right at the start of their formal schooling and their participation in pre-primary education was somewhat mixed. Where such learners could not read enough letters for a single word, their oral reading fluency was scored as zero, rather than recorded as missing, as this would have inflated the average performance by running the analyses with data for proficient readers only. Nevertheless, several Primary 1 pupils *did* progress to the more advanced rounds and this variation explains the large standard deviation relative to the mean for scores on the earlier measures of the assessment.

By contrast, the vast majority of Primary 4 learners displayed at least basic, if not good, emerging reading skills. On average, the older pupils read 41.61 words correctly per minute, which is well within the range of 33 to 47 words necessary to achieve a minimum level of reading fluency in Kinyarwanda (Moulton, 2016). Compared to previous studies of literacy in Rwanda, the Primary 4 participants also fared reasonably well. Table 5.11 below shows the percentage of children achieving specified reading speeds in a 2011 study and the present research, while the histograms in Figure 5.3 depict the distribution of Primary 1 and 4 learners' reading scores. In particular, the chart on the left shows the younger children performing largely at floor while the scores of the older pupils on the right show a broadly normal distribution, albeit with a slight positive skew.

Table 5.11 - Comparison of the Percentage of Primary 4 Pupils' Reading Speeds

Reading Ranges (words correct per minute)	Percentage of Primary 4 Pupils	
	RTI 2011	Current Study
0	13.00	1.31
1-15	13.00	1.30
16-30	35.00	14.38
31-45	30.00	52.94
46-60	7.00	18.96
61-75	2.00	9.15
75>	-	1.96

Source: Primary data, 2018; RTI International (2012). Notes: This table compares the percentage of children achieving specified oral reading fluency speeds between a 2011 study and the current research. The variation between the percentage columns could be attributable to multiple factors, not least sampling differences or changes to the way that Rwandan teachers taught reading between 2011 and 2018. Mostly importantly, however, the figures show that the data from the present research are broadly comparable with those from other studies.

Regarding gender, Table 5.10 revealed some small variation in the scores of girls and boys on the different measures of emerging literacy. However, once disaggregated for learners' class grade, as shown in Appendix 13, there is no discernible pattern to indicate a consistent difference in performance between pupils according to their gender. Nevertheless, the regressions described in sections 5.4.3 and 5.4.4 below control for children's gender because other studies on Rwandan learners' reading skills have shown statistically significant differences between girls and boys (Moulton, 2016).

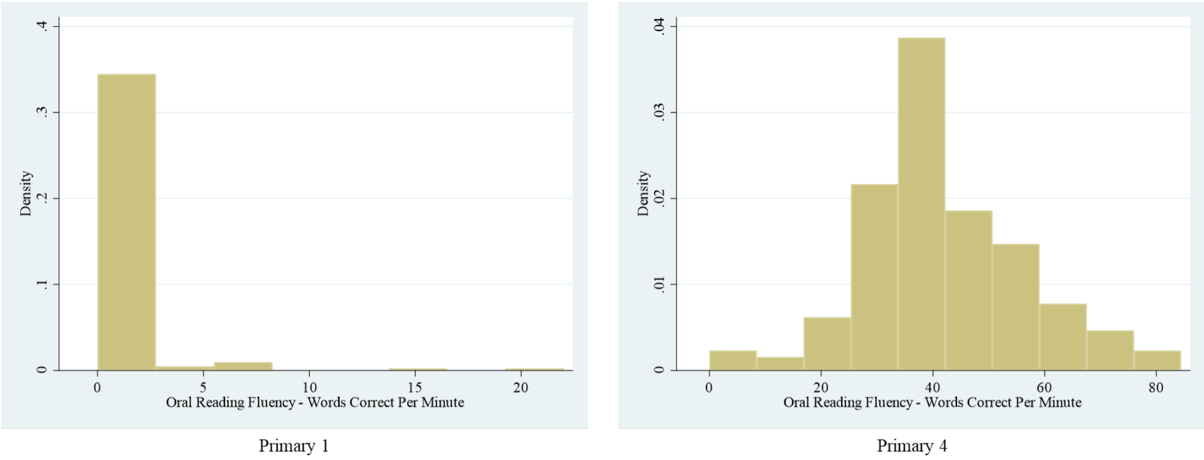


Figure 5.3 - Comparison of Primary 1 and 4 Oral Reading Fluency

Source: Primary data, 2018. Notes: This figure shows comparative histograms representing Primary 1 and 4 pupils' oral reading fluency, calculated as the number of Kinyarwanda words read correctly in a minute.

Similarly, there did not appear to be visible differences between pupils' comprehension scores based on the type of question they were asked, locator or inferential. Table 5.12 below show the types of questions asked in each exercise and the percentage of children who read the relevant sentence and answered the question correctly. In both cases, there is at least one locator question that fewer learners could answer, suggesting that the question type did not materially affect pupils' ability to provide a suitable response.

Table 5.12 - Percentage of Comprehension Questions Answered Correctly by Type

Reading Comprehension Activities A			Reading Comprehension Activities B		
Question	Type	Percentage Correct	Question	Type	Percentage Correct
1	Locator	97.45	1	Locator	70.13
2	Inferential	86.71	2	Inferential	53.90
3	Locator	77.85	3	Inferential	53.25
4	Locator	88.61	4	Locator	25.97
5	Locator	89.87	5	Locator	13.64

Source: Primary data, 2018. Notes: This table shows the type of comprehension questions and the percentage of Rwandan pupils who answered them correctly.

Regarding reliability, Table 3.8 above reported Cronbach's alpha for the key components of the EGRA measure with primary learners in Rwanda. In each case, the alpha exceeded the accepted minimum threshold of .70 expected for low-stakes assessments (Education Development Center, Inc., 2017; Field, 2009; RTI International, 2012, 2016). In the present research, I calculated reliability coefficients for the comprehension scores only, being seemingly unreported in previous studies[42]. The alpha for the first and second exercises were .71 and .54 respectively, and .66 across the two rounds. In particular, the reliability of pupils' responses to comprehension questions on the second reading passage was somewhat low, which could reflect the increasing complexity of the text or the time pressure on learners to read a longer story within the same time frame.

More importantly, however, the performance of most Primary 1 children at floor raises queries concerning the use of the same tasks across the two class cohorts. As indicated in section 3.6.3, the Rwandan learners undertook the combined EGRA-FARS assessments as criterion-referenced tests with 'stop' rules to compare attainment between the grades and thereby estimate pupils' literacy acquisition since the start of their primary schooling. Indeed, several Primary 1 children did progress to the more advanced tasks and some even answered the comprehension questions correctly. Using established measures further avoided the practical challenge and expense of developing and validating new tests for reading in Kinyarwanda. However, overall, too few of the younger learners reached the comprehension exercises to offer meaningful data on their cohort and so the Primary 1 comprehension scores were excluded from the subsequent analyses. Similarly, low levels of reading fluency among the younger Rwandan pupils suggest reduced reliability for the test instruments with this group. In turn, this could affect the validity of the research findings and increase error in the models for how children's cognitive flexibility relates to their emerging reading skills.

5.4.2 Correlations between Literacy and Cognitive Flexibility

Building on the approaches described in sections 5.2 and 5.3, I ran analyses to explore the correlations between learners' reading skills and their cognitive flexibility. Table 5.13 shows the Pearson's correlation coefficients between the main measures of literacy, pupils' oral

[42] Detailed reliability analysis to calculate Cronbach's alpha for each stage of the literacy assessments was impeded by the use of paper scoresheets and therefore deemed to be beyond the scope of this study.

reading fluency and comprehension, and their cognitive flexibility for the combined, Primary 1 and Primary 4 datasets. The tables in Appendix 13 further show the associations between all relevant sub-tasks and their significance, where appropriate.

Table 5.13 - Summary of Correlations between Reading Skills and Cognitive Flexibility Scores

Variable	**Combined**		**Primary 1**		**Primary 4**	
	Fluency	**Comp.**	**Fluency**	**Comp.**	**Fluency**	**Comp.**
Combined Cognitive Flexibility	.62***	.08	.03	.16	.16*	.04
DCCS Ratio (proportion)	.39***	.08	.02	.17	.07	.06
FIST Proportion	.63***	.05	.03	.08	.17*	.01
FIST Abstraction	.56***	-.06	.06	.16	.10	-.11
FIST Shifting	.63***	.10	.00	-.01	.19*	.08

Source: Primary data, 2018. $*p < .05$, $***p < .001$. Notes: Fluency is determined by the average number of words pupils read accurately per minute while the Comprehension score indicates the mean proportion of correct answers across the two comprehension exercises. The DCCS Ratio and FIST Proportion variables show a child's proportion of correct matches across the respective tasks, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for these two variables. Further, the FIST Abstraction score represents the proportion of first matches correct across the measure and FIST Shifting denotes the proportion of correct subsequent matches.

The tables reveal several key findings. First, there is no significant relationship between any one measure of the children's cognitive flexibility and their reading comprehension. This surprising lack of association holds true even when the data are disaggregated and analysed for Primary 1 and Primary 4 pupils separately, and appears to conflict with research by Cartwright (2008, 2009, 2012) who emphasises the importance of cognitive flexibility for developing reading comprehension. Second, there is some, albeit limited, evidence of a statistically significant association between Primary 4 learners' oral reading fluency and their combined cognitive flexibility score ($r = .16$, $p < .05$), specifically their performance on the FIST ($r = .17$, $p = .03$) and the shifting component of the task ($r = .19$, $p = .02$).

Finally, and by contrast, the correlations for the Primary 1 data show no consistent relationship between pupils' oral reading fluency and their scores on the cognitive flexibility assessments. However, while the values relating to Primary 1 children's oral reading fluency are notionally continuous, ranging from zero to a maximum of 22 words read correctly per minute, the first chart in Figure 5.3 shows that they tend to be more binary, with the majority of pupils performing at floor and only a small number able to read one or more words. For this reason, I also grouped the Primary 1 learners according to their reading scores to create binary, categorical and ordinal variables and used independent *t*-tests, ANOVAs and Spearman's rank correlation coefficient to examine their relationship with reading fluency. Table 5.14 below shows the results of the different bivariate analyses and reveals that there are some statistically significant associations between pupils' fluency and some measures of the FIST, particularly relating to the abstraction component.

Table 5.14 - Summary of Primary 1 Bivariate Analyses with Reading Variables

Variable	Binary variable – *t*-test		Categorical variable – ANOVA		Ordinal variable – Spearman's coefficient	
	t-value	Sig.	*F*-value	Sig.	*r*	Sig.
Combined Cognitive Flexibility	-1.30	.21	1.06	.37	.13	.10
DCCS Ratio (proportion)	-0.73	.47	0.19	.90	.08	.31
FIST Proportion	-1.29	.22	2.55	.06	.17	.03
FIST Abstraction	-1.82	.09	2.37	.07	.19	.02
FIST Shifting	-0.75	.46	2.01	.11	.02	.81

Source: Primary data, 2018. Notes: Children's reading fluency, being binary, categorical or ordinal, is determined by the average number of words pupils could read accurately per minute. The DCCS Ratio and FIST Proportion variables show a child's proportion of correct matches across the respective tasks, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for these two variables. Further, the FIST Abstraction score represents the proportion of first matches correct across the measure and FIST Shifting denotes the proportion of correct subsequent matches.

In summary, there is evidence among Primary 4 pupils and, to a certain extent, Primary 1 learners of some relationship between Rwandan children's emerging reading skills and their cognitive flexibility. Building on these correlations, I therefore conducted various regressions to determine whether learners' performance on the cognitive flexibility measures also significantly predicted their oral reading fluency.

5.4.3 Predicting Oral Reading Fluency

In the first analysis, I ran a logistic regression taking into account the binary nature of the Primary 1 pupils' responses. Logistic regressions are commonly used in situations with clear dichotomous outcomes, in this case children's ability or inability to read any words correctly in Kinyarwanda. Unlike ordinary least squares regressions, logistic regressions do not presume a linear relationship or a normal distribution but estimate how much the natural logarithm of the odds for the dependent variable changes for a one-unit change in the explanatory variable (Mehmetoglu & Jakobsen, 2017).

Regarding predictors, the proportional FIST score showed a statistically significant association in Table 5.14 and so comprised the main explanatory variable in the first model, while the combined cognitive flexibility score predicted learners' reading in the second. Performance on the DCCS was omitted from both regressions for lack of significant correlation, while the FIST abstraction and shifting variables were excluded to avoid issues of multicollinearity. Following the approaches outlined in sections 5.2.3 and 5.3.3, I also controlled for several background and design-based factors, some of which showed significant associations with children's cognitive flexibility, as discussed in Chapter 4.

Table 5.15 below sets out the key regression statistics and reveals that Primary 1 learners' cognitive flexibility, and specifically the combined score, significantly predicted their ability to read any Kinyarwanda words at the 5 per cent level. In particular, the odds of a Primary 1 child reading one or more words correctly were 2.94 times higher for each additional standard deviation that he or she achieved on the combined cognitive flexibility measure. The results also indicate that pupils who reported repeating at least one year of primary education were 4.09 to 4.40 times more likely to be able to read full words than their peers, holding other factors constant.

Unlike the Primary 1 responses, data for Primary 4 learners' literacy were more normally distributed and so the second analysis used multivariate linear regressions, treating pupils' standardised oral reading fluency scores as the dependent outcome variable. Regarding potential predictors, Table 5.13 showed a statistically significant correlation with pupils' overall cognitive flexibility score (r = .16, p < .05), which comprises a combination of their performance on the DCCS and FIST tasks. Between the two, children's attainment on the FIST displayed a stronger association with their ability to read words quickly and accurately, but their switching skills measured by the DCCS also displayed a positive and significant relationship with their proficiency to identify and sound letters (r = .16, p < .05), a precursor to their reading fluency. In which case, I ran regressions using each of the DCCS, FIST and combined cognitive flexibility scores as the main explanatory variables, controlling for numerous household, school- and design-based factors that showed significant associations with Primary 4 learners' cognitive flexibility, being listed in section 5.2.3.

Table 5.15 - Logistic Regression Odds Ratios for Primary 1 Pupils' Reading Fluency

	(1)	(2)
FIST Proportion	2.27 (0.97)	-
Combined Cognitive Flexibility	-	2.94 (1.59)*
Gender	1.48 (0.96)	1.42 (0.94)
Pupil age	1.18 (0.92)	0.92 (0.74)
Drank before school	2.38 (1.83)	2.62 (2.05)
Meals per day	0.75 (0.36)	0.88 (0.43)
Frequency of eating fish	0.88 (0.22)	0.95 (0.23)
Years of pre-primary	1.50 (0.38)	1.60 (0.42)
Repeated any primary	4.40 (2.95)*	4.09 (2.71)*
School		
- School 2	4.32 (6.05)	3.57 (5.07)
- School 3	4.49 (6.48)	3.69 (5.44)
- School 4	1.83 (1.80)	1.97 (1.93)
Enumerator		
- Enumerator 2	0.63 (0.78)	0.42 (0.54)
- Enumerator 3	1.29 (1.39)	1.06 (1.17)
- Enumerator 4	5.28 (7.62)	3.87 (5.56)
Constant	0.00 (0.01)	0.01 (0.06)
Pseudo R-squared	.16	.17
Observations	151	151

Source: Primary data, 2018. *$p < .05$. Notes: This table shows the logistic regression odds ratios, standard error and statistical significance of predictor variables in logistic regressions for Primary 1 pupils' oral reading fluency, based on whether or not they could read any words correctly in a minute. The FIST Proportion variable show a child's proportion of correct matches on the FIST, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for the FIST and the DCCS measures.

Table 5.16 below sets out the key regression statistics for the Primary 4 learners' oral reading fluency. Overall, the models do not show a good level of fit, with the R^2 values indicating that they explain up to 13 per cent of the variance in pupils' reading skills. However, this value drops to around zero when the number of variables is taken into account. Most importantly, none of the cognitive flexibility measures significantly predicted Primary 4 children's oral reading fluency at the 5 per cent level, although the *p*-value for the FIST proportion score is low (p = .06). Similar to the other cognitive competencies, gender appears unrelated to learners' performance and only two design-based factors significantly predicted their reading skills. Specifically, pupils undertaking the literacy assessments with one particular research assistant scored up to 54 per cent of a standard deviation *lower* on the fluency measures than those tested by the first enumerator, reading up to 12.45 words correctly per minute *fewer* after holding all other variables constant. Likewise, children attending School 2 performed up to 38 per cent of a standard deviation, or 8.76 words per minute, worse on the reading assessments than those in School 1, after controlling for other factors.

Finally, I combined the data for both Primary 1 and Primary 4 cohorts and ran stepwise regressions to investigate the extent to which learners' performance on the cognitive flexibility measures across the class grades predicted their oral reading fluency, conditional on significant background, educational and design-based factors. I followed the same approaches described in sections 5.2.3 and 5.3.3, introducing class grade, control variables and then the two separate measures for cognitive flexibility, the DCCS and the FIST.

Table 5.17 shows the statistics for the four stepwise models, which on face value suggest a high level of fit. The R^2 figures imply that the models may explain up to 83 per cent of variance in pupils' oral reading fluency, or 81 per cent when adjusted for the number of variables (adjusted R^2). Regarding cognitive flexibility, the first two models suggest that it predicted learners' reading skills, but this association disappears once class grade and background factors are taken into account.

Indeed, only two variables appeared to significantly predict learners' oral reading fluency at the 5 per cent level or below. First, and similar to the other cognitive competencies, the Rwandan children's class grade was the strongest predictor of their reading skills. After controlling for other variables, Primary 4 pupils achieved up to 1.76 standard deviations higher and read up to 40.57 words correctly per minute more than those in Primary 1. Second, children who reported repeating at least one year of primary school performed worse than their peers overall, scoring 22 per cent of a standard deviation lower on oral fluency and reading 5.07 words per minute fewer, after controlling for other variables, $b = -0.22$, $p < .01$.

Table 5.16 - Regression Coefficients (Standard Errors) for Primary 4 Pupils' Reading Fluency

	(1)	(2)	(3)
DCCS Ratio (proportion)	0.00 (0.06)	-	-
FIST Proportion	-	0.13 (0.07)	-
Combined Cognitive Flexibility	-	-	0.11 (0.09)
Gender	0.00 (0.11)	-0.01 (0.11)	-0.01 (0.11)
Pupil age	-0.11 (0.11)	-0.14 (0.11)	-0.12 (0.11)
Family structure			
- Non-relative guardian(s)	0.62 (0.66)	0.58 (0.65)	0.67 (0.65)
- Non-parent family guardian(s)	-0.09 (0.23)	-0.11 (0.22)	-0.12 (0.23)
- Single parent family	-0.02 (0.13)	-0.05 (0.12)	-0.05 (0.13)
Family environment (stress)	-0.26 (0.18)	-0.25 (0.18)	-0.25 (0.18)
Multilingual household	0.01 (0.04)	0.01 (0.04)	0.00 (0.04)
Frequency of family reading	-0.02 (0.04)	-0.02 (0.04)	-0.02 (0.04)
Number of family readers	0.02 (0.16)	0.04 (0.16)	0.02 (0.16)
House type			
- Basic house	0.06 (0.17)	0.05 (0.17)	0.06 (0.17)
- Large house	-0.10 (0.12)	-0.09 (0.12)	-0.08 (0.12)
School			
- School 2	-0.38 (0.18)*	-0.34 (0.18)	-0.36 (0.18)*
- School 3	-0.21 (0.17)	-0.10 (0.18)	-0.16 (0.17)
- School 4	-0.17 (0.17)	-0.05 (0.18)	-0.12 (0.17)
Enumerator			
- Enumerator 2	-0.22 (0.20)	-0.20 (0.20)	-0.23 (0.20)
- Enumerator 3	-0.28 (0.16)	-0.22 (0.16)	-0.27 (0.16)
- Enumerator 4	-0.54 (0.20)**	-0.45 (0.20)*	-0.51 (0.20)*
Constant	2.64 (1.20)*	2.69 (1.19)*	2.62 (1.20)*
R-squared	.10	.13	.11
Adjusted R-squared	-.02	.01	-.01
Observations	149	149	149

Source: Primary data, 2018. $*p < .05$, $**p < .01$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Primary 4 pupils' oral reading fluency, based on their number of words read correctly in a minute. The DCCS Ratio (Proportion) and FIST Proportion variables show a child's proportion of correct matches on the respective task, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for the DCCS and the FIST measures.

Table 5.17 - Multivariate Regression for Rwandan Pupils' Oral Reading Fluency

	(1)	(2)	(3)	(4)
Combined Cognitive Flexibility	0.76 (0.05)***	0.80 (0.04)*	0.07 (0.04)	-
DCCS Ratio (proportion)	-	-	-	0.01 (0.03)
FIST Proportion	-	-	-	0.07 (0.04)
Gender	-	-	0.04 (0.05)	0.04 (0.05)
Class grade	-	1.69 (0.07)***	1.76 (0.07)***	1.74 (0.08)***
Family structure				
- Non-relative guardian(s)	-	-	0.13 (0.45)	0.08 (0.45)
- Non-parent family guardian(s)	-	-	-0.04 (0.12)	-0.04 (0.12)
- Single parent family	-	-	-0.01 (0.06)	0.00 (0.06)
Drank before school	-	-	-0.03 (0.06)	-0.02 (0.06)
Meals per day	-	-	0.03 (0.04)	0.03 (0.04)
Frequency of eating fish	-	-	0.02 (0.02)	0.02 (0.02)
Family environment (stress)	-	-	-0.10 (0.07)	-0.10 (0.07)
Multilingual household	-	-	-0.01 (0.02)	-0.01 (0.02)
Frequency of family reading	-	-	-0.01 (0.02)	-0.02 (0.02)
Number of family readers	-	-	0.00 (0.10)	0.01 (0.10)
House type				
- Basic house	-	-	0.05 (0.08)	0.04 (0.08)
- Large house	-	-	0.00 (0.06)	0.00 (0.06)
Years of pre-primary	-	-	0.01 (0.02)	0.01 (0.02)
Repeated any primary	-	-	-0.22 (0.05)***	-0.22 (0.05)***
School				
- School 2	-	-	-0.13 (0.09)	-0.12 (0.09)
- School 3	-	-	-0.08 (0.09)	-0.06 (0.09)
- School 4	-	-	-0.08 (0.08)	-0.06 (0.08)
Enumerator				
- Enumerator 2	-	-	-0.05 (0.10)	-0.03 (0.10)
- Enumerator 3	-	-	-0.09 (0.08)	-0.07 (0.08)
- Enumerator 4	-	-	-0.19 (0.10)	-0.16 (0.11)
Constant	0.00 (0.04)	-0.85 (0.04)***	-0.71 (0.17)***	-0.72 (0.17)***
R-squared	.39	.80	.83	.83
Adjusted R-squared	.39	.80	.81	.81
Observations	306	306	294	294

Source: Primary data, 2018. $*p < .05$, $***p < .001$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Rwandan pupils' oral reading fluency, based on their number of words read correctly in a minute. The DCCS Ratio (Proportion) and FIST Proportion variables show a child's proportion of correct matches on the respective task, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for the DCCS and the FIST measures.

Notwithstanding these findings, post-regression tests nevertheless reveal that the models do not meet all of the assumptions that underlie parametric analysis. Variance inflation factors of around 1.95 indicate that multicollinearity between variables does not present a problem, however, heteroscedasticity and non-normality in the data potentially create bias and error that may affect their generalisability. Specifically, results for the Breusch-Pagan/Cook-Weisberg test show significant deviations from homoscedasticity (in each case, $p < .01$), while the Shapiro-Wilk test indicates that the standardised residuals materially depart from normality ($p < .01$).

To a certain extent, the data's non-compliance with the parametric assumptions is not altogether unexpected. While the EGRA and FARS have been established and validated in Rwandan schools, they have typically been used with older learners, rather than pupils right at the start of their primary education. Indeed, 35 per cent of the Primary 1 children reported that they had not attended any pre-primary schooling and for those that did, the quality of such provision remains unknown. For these reasons, and the questions around reliability raised in section 5.4.1, it is unsurprising that the majority of young learners could not read many, if any, familiar words and that their oral reading fluency was generally at floor.

In summary, there appears to be a limited relationship between Rwandan pupils' cognitive flexibility and their oral reading fluency. Among Primary 1 children, there is some evidence that performance on cognitive flexibility measures may predict the likelihood that they can read one or more words in Kinyarwanda, but such associations disappear at the Primary 4 level and when combining the two cohorts. As with non-verbal reasoning and global executive function, learners' class grade remains a stronger and more consistent predictor of Rwandan children's reading skills.

5.4.4 Cognitive Flexibility and Reading Comprehension

Beyond reading *fluency*, and as indicated in section 5.4.1, there was limited data available on learners' reading *comprehension* and their ability to understand the Kinyarwanda passages they read. Only six and four Primary 1 children reached the first and second comprehension exercises respectively, too few cases to enable meaningful statistical analysis. Even among Primary 4 pupils, the correlations in Table 5.13 revealed no evidence of a relationship between their cognitive flexibility and reading comprehension, in contrast to the research by Cartwright (2008, 2009, 2012).

To confirm this lack of association, I conducted regressions with the Primary 4 data to test whether any of the cognitive flexibility variables, the DCCS, FIST or combined measure, significantly predicted their reading comprehension. Noting the correlation between pupils' comprehension and their reading speed ($r = .28$, $p < .01$), I also controlled for their oral reading fluency in a second set of regressions.

The results of the analyses are set out in Appendix 13. As expected, they show that there is no significant relationship between Rwandan Primary 4 learners' reading comprehension and any measure of their cognitive flexibility. Indeed, only two variables predicted pupils' comprehension scores: their oral reading fluency and family environment. Specifically, for each standard deviation of oral fluency or 23.05 words that a child could correctly read in a minute, he or she scored approximately 45 per cent of a standard deviation higher on the comprehension measure, holding other factors constant. By contrast, those learners who reported living in stressful families and households scored between 78 and 91 per cent of a standard deviation *lower* on the comprehension variable, after controlling for other factors.

In summary, the research data show no clear and consistent relationship between Rwandan pupils' cognitive flexibility and their reading skills. There is some, albeit limited, evidence of an association between cognitive flexibility and early word decoding, but seemingly no relationship with reading comprehension. Between the two aspects of literacy assessed, reading fluency and comprehension, there *is* nevertheless a significant association and this provides encouraging insight that the Primary 4 learners participating in the study were not just learning to decode words in Kinyarwanda, but they could also derive some meaning from the texts they were reading.

However, these analyses and those described in sections 5.2 and 5.3 only explored the extent to which cognitive flexibility contributed to or predicted Rwandan children's literacy, non-verbal reasoning and executive function. The next section therefore examines whether the reverse could also be true, specifically whether such competencies might similarly predict Rwandan pupils' cognitive flexibility.

5.5 Predicting Cognitive Flexibility

To investigate this relationship, I conducted a final set of stepwise regressions which built on the models for cognitive flexibility development described in Chapter 4. Following the approaches adopted above, I ran separate regressions for Primary 1 and 4 learners before combining them into a common model.

In each case, the combined cognitive flexibility score comprised the dependent outcome variable while standardised measures for non-verbal reasoning, executive function and reading were included as the explanatory variables. For the Primary 1 regression, only the binary variable for reading fluency was used, whereas the Primary 4 model included the continuous scores for both reading fluency and comprehension. In the second model for each cohort, I also controlled for various background, educational and design-based factors listed above as showing significant associations with pupils' cognitive flexibility.

Before conducting the regressions, and to avoid the problem of multicollinearity, I checked for correlations between the different competency measures. Table 5.18 sets out the relevant Pearson's correlation coefficients for the combined datasets and disaggregated by class grade. Overall, there are numerous statistically significant associations, particularly for the combined data, but no coefficients in excess of .80 that would give rise to material multicollinearity or warrant the omission of any one variable (Field, 2009). A detailed discussion on the correlations between such competencies and their practical or psychological significance is beyond the scope of this study.

Table 5.18 - Summary of Correlations between the Cognitive Competencies

Variable	Combined				Primary 1				Primary 4			
	1.	2.	3.	4.	1.	2.	3.	4.	1.	2.	3.	4.
1. Non-verbal Reasoning	1.00	-	-	-	1.00	-	-	-	1.00	-	-	-
2. Global Executive Function	.44***	1.00	-	-	.24**	1.00	-	-	.09	1.00	-	-
3. Oral Reading Fluency	.53***	.54***	1.00	-	.06	.16*	1.00	-	.04	.04	1.00	-
4. Reading Comprehension	.13	.13	.28***	1.00	-	-	-	1.00	.11	.09	.28***	1.00

Source: Primary data, 2018. **p* < .05, ***p* < .01, ****p* < .001. Notes: Correlations with Primary 1 comprehension scores are excluded due to the low number of participants. Pupils' Non-verbal reasoning performance is determined based on their proportion of correct items selected in the OPRA task, while Global Executive Function reflects scores on the Tower of Hanoi over a maximum of seven trials. Oral Reading Fluency is calculated as the average number of words learners could read accurately per minute while the Comprehension score indicates the mean proportion of correct answers across the two comprehension exercises.

Table 5.19 below shows the results of the Primary 1 regressions. To facilitate easy comparison, the final column of this and subsequent tables sets out the coefficients, standard errors and significance of the corresponding regressions in Chapter 4. Overall, the combined model (2) which includes both cognitive competency measures and background variables explains the most variance, 23 per cent, in Primary 1 pupils' cognitive flexibility, or 14 per cent when accounting for the number of factors (adjusted R^2). Most importantly, the results reveal that the younger learners' global executive function significantly predicted their cognitive flexibility even after controlling for different household and educational variables. Specifically, one standard deviation on the Tower of Hanoi task accounted for an extra 15 per cent of a standard deviation on the combined cognitive flexibility score, holding other factors constant, $b = 0.15$, $p = .01$. In addition, the model indicates that children performed significantly better on cognitive flexibility measures when undertaking the assessment with a particular enumerator, again after controlling for other variables, $b = 0.37$, $p = .04$.

The data for Primary 4 pupils show slightly different results, being set out in Table 5.20. Among the older learners, non-verbal reasoning but not executive function significantly predicted their cognitive flexibility. For each standard deviation on the OPRA, the Primary 4 children scored 18 per cent of a standard deviation higher on the combined cognitive flexibility measure, holding other factors constant, $b = 0.18$, $p < .01$. Two other categories of variables further predicted the Primary 4 pupils' cognitive flexibility. First, learners from single-parent families performed better on the switching and shifting tasks than their peers from two-parent families, even after controlling for background factors and their other competencies, $b = 0.29$, $p = .02$. Second, the Primary 4 children in two of the schools achieved significantly worse scores on the cognitive flexibility measures than those in the base case school, 44 and 54 per cent of a standard deviation lower, again holding other variables constant including their reading skills and global executive function.

Table 5.19 - Regression Coefficients (Standard Errors) for Primary 1 Pupils' Cognitive Flexibility

	(1)	(2)	(3)
Non-verbal Reasoning	0.06 (0.08)	0.04 (0.08)	-
Global Executive Function	0.14 (0.08)*	0.15 (0.06)*	-
Oral Reading Fluency (Binary)	0.15 (0.17)	0.24 (0.17)	-
Gender	-	-0.06 (0.10)	-
Pupil age	-	0.16 (0.11)	0.21 (0.11)
Drank before school	-	-0.14 (0.11)	-0.19 (0.11)
Meals per day	-	-0.04 (0.08)	-0.04 (0.08)
Frequency of eating fish	-	-0.07 (0.04)	-0.07 (0.04)
Years of pre-primary	-	-0.05 (0.03)	-0.03 (0.03)
Repeated any primary	-	-0.02 (0.11)	-0.01 (0.11)
School			
- School 2	-	-0.01 (0.18)	0.02 (0.18)
- School 3	-	-0.02 (0.19)	-0.07 (0.19)
- School 4	-	-0.03 (0.14)	0.00 (0.15)
Enumerator			
- Enumerator 2	-	0.37 (0.18)*	0.28 (0.18)
- Enumerator 3	-	0.00 (0.15)	0.01 (0.15)
- Enumerator 4	-	0.03 (0.21)	-0.02 (0.21)
Constant	-0.43 (0.07)***	-1.28 (0.85)	-1.72 (0.84)*
R-squared	.06	.23	.16
Adjusted R-squared	.05	.14	.09
Observations	153	151	151

Source: Primary data, 2018. *$p < .05$, ***$p < .001$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Primary 1 pupils' cognitive flexibility, based on their combined score across the DCCS and FIST tasks. Non-verbal reasoning performance is determined based on their proportion of correct items selected in the OPRA task, while Global Executive Function reflects scores on the Tower of Hanoi over a maximum of seven trials. The binary measure for Oral Reading Fluency indicates whether or not the child could read any words correctly in Kinyarwanda.

Table 5.20 - Regression Coefficient (Standard Errors) for Primary 4 Pupils' Cognitive Flexibility

	(1)	(2)	(3)
Non-verbal Reasoning	0.16 (0.05)**	0.18 (0.06)**	-
Global Executive Function	0.07 (0.07)	0.10 (0.07)	-
Oral Reading Fluency	0.12 (0.09)	0.06 (0.09)	-
Reading Comprehension	-0.01 (0.05)	0.00 (0.06)	-
Gender	-	0.10 (0.10)	-
Pupil age	-	0.05 (0.11)	-
Family structure			
- Non-relative guardian(s)	-	-0.62 (0.63)	-0.47 (0.63)
- Non-parent family guardian(s)	-	0.36 (0.22)	0.29 (0.22)
- Single parent family	-	0.29 (0.12)*	0.29 (0.12)*
Family environment (stress)	-	0.03 (0.18)	-0.16 (0.17)
Multilingual household	-	0.01 (0.04)	0.03 (0.04)
Frequency of family reading	-	-0.01 (0.04)	0.00 (0.04)
Number of family readers	-	0.07 (0.15)	0.03 (0.15)
House type			
- Basic house	-	-0.08 (0.16)	0.01 (0.16)
- Large house	-	-0.14 (0.11)	-0.17 (0.11)
School			
- School 2	-	-0.23 (0.17)	-0.25 (0.17)
- School 3	-	-0.44 (0.16)**	-0.51 (0.16)**
- School 4	-	-0.54 (0.16)**	-0.52 (0.16)**
Enumerator			
- Enumerator 2	-	0.18 (0.19)	0.06 (0.19)
- Enumerator 3	-	0.01 (0.15)	-0.08 (0.15)
- Enumerator 4	-	-0.16 (0.19)	-0.22 (0.19)
Constant	0.31 (0.10)**	0.05 (1.16)	0.88 (0.22)***
R-squared	.08	.28	.20
Adjusted R-squared	.06	.16	.11
Observations	151	148	149

Source: Primary data, 2018. $*p < .05$, $**p < .01$, $***p < .001$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Primary 4 pupils' cognitive flexibility, based on their combined score across the DCCS and FIST tasks. Non-verbal reasoning performance is determined based on their proportion of correct items selected in the OPRA task, while Global Executive Function reflects scores on the Tower of Hanoi over a maximum of seven trials. Oral Reading Fluency is calculated as the average number of words learners could read accurately per minute while the Comprehension score indicates the mean proportion of correct answers across the two comprehension exercises.

Finally, Table 5.21 shows the coefficients for the combined dataset and the stepwise regressions. In these models, the variable for pupils' reading comprehension was omitted given the low number of Primary 1 values[43]. Overall, the results for the third regression in particular indicate a good level of fit, explaining 53 per cent of variance in children's cognitive flexibility, or 48 per cent once the number of variables is taken into account (adjusted R^2). Similar to the models for non-verbal reasoning, executive function and reading fluency, learners' class grade emerges as the strongest predictor of their cognitive flexibility, with pupils in Primary 4 achieving 53 per cent of a standard deviation higher than those in Primary 1, after controlling for other factors, $b = 0.53$, $p < .01$.

However, of greatest relevance for the current study, the measures for both non-verbal reasoning and executive function significantly predicted children's cognitive flexibility. In both cases, a standard deviation on the OPRA and Tower of Hanoi tasks accounted for an additional 12 per cent of a standard deviation on the combined cognitive flexibility score, holding other variables constant, $b = 0.12$, $p = .01$. By contrast, the results show no consistent or significant association between learners' cognitive flexibility and their reading skills, and neither Table 5.20 nor 5.21 indicate that pupils' reading comprehension or fluency respectively predicted their performance on the switching and shifting tasks.

[43] Post-regression analyses also revealed some collinearity between pupils' class grade and their reading fluency, which was unsurprising given the results described in section 5.4. In light of this, I conducted further regressions without the separate fluency variable, however, the significance of the other variables remained unchanged. Only the size of the class grade coefficient increased and so these additional regressions are not reported.

Table 5.21 - Regression Coefficients (Standard Errors) for Pupils' Cognitive Flexibility

	(1)	(2)	(3)	(4)
Non-verbal Reasoning	0.16 (0.04)***	0.13 (0.04)**	0.12 (0.04)**	-
Global Executive Function	0.14 (0.04)**	0.11 (0.04)*	0.12 (0.04)**	-
Oral Reading Fluency	0.35 (0.05)***	0.14 (0.08)	0.13 (0.08)	-
Gender	-	-	-0.01 (0.07)	-
Class grade	-	0.55 (0.16)**	0.53 (0.18)**	1.04 (0.08)***
Family structure				
- Non-relative guardian(s)	-	-	-0.44 (0.62)	-0.42 (0.63)
- Non-parent family guardian(s)	-	-	0.16 (0.16)	0.17 (0.16)
- Single parent family	-	-	0.09 (0.08)	0.09 (0.09)
Drank before school	-	-	-0.09 (0.08)	-0.11 (0.08)
Meals per day	-	-	-0.01 (0.06)	-0.03 (0.06)
Frequency of eating fish	-	-	-0.02 (0.03)	-0.02 (0.03)
Family environment (stress)	-	-	0.06 (0.10)	-0.03 (0.10)
Multilingual household	-	-	0.05 (0.03)	0.04 (0.03)
Frequency of family reading	-	-	0.00 (0.03)	0.01 (0.03)
Number of family readers	-	-	0.02 (0.14)	-0.05 (0.14)
House type				
- Basic house	-	-	-0.11 (0.12)	-0.11 (0.12)
- Large house	-	-	-0.14 (0.08)	-0.17 (0.08)*
Years of pre-primary	-	-	-0.03 (0.02)	-0.02 (0.02)
Repeated any primary	-	-	0.07 (0.08)	0.04 (0.08)
School				
- School 2	-	-	-0.15 (0.12)	-0.15 (0.13)
- School 3	-	-	-0.27 (0.12)*	-0.34 (0.13)**
- School 4	-	-	-0.19 (0.11)	-0.17 (0.11)
Enumerator				
- Enumerator 2	-	-	0.16 (0.13)	0.08 (0.13)
- Enumerator 3	-	-	-0.01 (0.11)	-0.04 (0.11)
- Enumerator 4	-	-	-0.16 (0.14)	-0.22 (0.15)
Constant	0.00 (0.04)	-0.27 (0.09)**	0.07 (0.24)	-0.06 (0.23)
R-squared	.45	.47	.53	.49
Adjusted R-squared	.44	.46	.48	.45
Observations	306	306	294	294

Source: Primary data, 2018. *$p < .05$, **$p < .01$, ***$p < .001$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Rwandan pupils' cognitive flexibility, based on their combined score across the DCCS and FIST tasks. Non-verbal reasoning performance is determined based on their proportion of correct items selected in the OPRA task, while Global Executive Function reflects scores on the Tower of Hanoi over a maximum of seven trials and Oral Reading Fluency is calculated as the average number of words learners could read accurately per minute.

5.6 Discussion

This chapter has explored the relationship between Rwandan children's cognitive flexibility and the development of their other competencies, specifically non-verbal reasoning, executive function and emerging literacy. While some of these interactions have been researched among learners in other contexts, the study seemingly represents the first attempt to apply such a methodology with low-income primary-aged pupils in Rwanda.

Overall, the data reveal significant associations between Rwandan children's cognitive flexibility and their non-verbal reasoning and global executive function. At both Primary 1 and 4 levels, performance on one or both measures of cognitive flexibility predicted learners' scores on the OPRA and Tower of Hanoi tasks, even after controlling for a range of household, educational and design-based factors. Conversely, pupils' performance on the non-verbal reasoning and executive function measures also significantly predicted their cognitive flexibility scores.

Between the cognitive competencies, there were nevertheless differences across the two school cohorts. For example, the relationship between global executive function and cognitive flexibility appeared strongest at the Primary 1 level. The former significantly predicted the latter and vice versa among Primary 1 children, but not within the Primary 4 cohort. By contrast, non-verbal reasoning predicted cognitive flexibility among Primary 4 but not Primary 1 pupils, holding all other factors constant. The reasons for these differences and their psychological relevance remain unknown, but could comprise the focus of future valuable research.

Similarly, the results show some variation between the two measures for cognitive flexibility. Although performance on the DCCS significantly predicted Primary 4 learners' non-verbal reasoning, there were generally stronger and more consistent associations between scores on the FIST and the other competency tasks. Evidently, pupils' shifting as assessed by the FIST appeared better related to their non-verbal reasoning and executive function than their DCCS switching, which might suggest that the former offers a better measure of cognitive flexibility for children in Rwanda.

Regarding literacy, the evidence of a clear relationship with cognitive flexibility is unconvincing. The results of logistic regressions summarised in Table 5.15 showed that Primary 1 learners' combined cognitive flexibility scores significantly predicted whether or not they could read any words in Kinyarwanda, but otherwise there appeared to be no association with pupils' oral reading fluency and comprehension. As discussed in section 5.4 above, this stands in contrast to research by Cartwright (2008, 2009, 2012) and others who have emphasised the importance of cognitive flexibility for the development of children's emerging reading skills in other contexts.

Across the regressions, the results show that learners' class grade, Primary 1 or Primary 4, was the strongest predictor of their performance on the various cognitive tasks. As noted above, the precise cause of the difference remains unknown and could relate to organic changes in children's maturity or the additive effects of formal education. In so far as cognitive flexibility development is concerned, however, Table 5.21 shows that improvements in pupils' competencies account for at least *some* of the difference, with the reduction of the class grade coefficient from 1.04 to 0.53 between the final two models.

In addition to cognitive flexibility, the data reveal several interesting findings pertaining to Rwandan children's wider learning. The first relates to class repetition. In particular, Primary 1 pupils who reported having repeated at least 1 year of prior education scored significantly higher on the non-verbal reasoning measure, around a third of a standard deviation, and were over four times as likely to be able to read at least one word in Kinyarwanda. However, when Primary 4 learners were taken into account, children who had repeated *any* years of primary education displayed significantly *worse* literacy, reading 5.07 fewer words correctly than their peers after controlling for other factors. This finding, specifically the apparent paradox between early learning advantages for Primary 1 repeaters contrasting with later disadvantages for older repeaters, aligns with the results of other studies among primary school pupils in Rwanda (Education Development Center, Inc., 2017; Moulton, 2016).

Second, there were significant differences between pupils according to the school they attended but these disparities were not straightforward or necessarily consistent across learning outcomes. For example, children in School 1 performed significantly better than those in Schools 3 and 4 on the cognitive flexibility measures, even after holding other factors constant, such as their class grade. However, learners in School 4 achieved significantly higher scores on the Tower of Hanoi task than those in School 1. Related to this, there were some discrepancies between children assessed by the different enumerators. For example, pupils undertaking the DCCS and FIST with one particular research assistant performed better than those tested by another, but the reverse was true for their executive function scores.

Third, the data reveal a negative association between children's learning and the tone of their home environment. Specifically, pupils were invited to indicate which of the two pictures in Figure 5.4 better represented their family interactions, not least given existing research on the effects of stress on children's executive function development (Blair, 2016; Diamond, 2016). Similar to the house pictures in Figure 4.8, the least favourable option was presented first to balance any pre-disposition among participants to select the most immediate and the most desirable choices. Overall, pupils who chose the first picture performed significantly worse on the non-verbal reasoning task, across both class cohorts, while the Primary 4 learners also scored worse on their reading comprehension.

Figure 5.4 - Representation of Different Rwandan Home Environments
(illustrations by Kabandana Casmir Pacifique)

The findings above must nevertheless be interpreted in light of several important caveats. First, in the absence of longitudinal data, they highlight statistically significant associations or differences between variables and responses but they cannot be used to impute any causal relationships. While the regressions enable the prediction of specific outcomes or performance based on explanatory factors, this does not indicate any actual causality between them. Second, and as noted above, the study did not capture data on children's numeracy, another core learning outcome in the Rwandan curriculum which could have links to pupils' cognitive flexibility, executive function or non-verbal reasoning (Engel de Abreu et al., 2014; MINEDUC, 2015). Finally, certain questions around the reliability of using the same measures across the class cohorts and whether the resultant data meet all assumptions for parametric analyses suggest the need for some caution in their interpretation at face value.

In summary and to address RQ2, this chapter explored the relationship between Rwandan learners' cognitive flexibility and their other important competencies. The results show several significant associations, with children's cognitive flexibility and particularly their FIST scores predicting performance on the non-verbal reasoning and executive function tasks, and vice versa. The precise relationships appear to vary by grade with stronger associations between cognitive flexibility and executive function at the Primary 1 level, and with non-verbal reasoning among the Primary 4 pupils. However, in contrast to wider literature, there is no robust evidence of a clear relationship between Rwandan children's cognitive flexibility and their reading fluency or comprehension.

To conclude, the data described in Chapter 4 revealed large differences in cognitive flexibility between learners in Primary 1 and 4, and the findings in this chapter go some way to explain that variation. Approximately half can be accounted for by improvements in non-verbal reasoning and global executive function, while the remainder may reflect the combined effects of children's natural maturation and the contribution of their formal education. Regarding the latter, teachers' practices and behaviours likely shape their pupils' cognitive development, but this in turn depends on the values and attitudes they bring into the classroom. Chapter 6 therefore explores these perceptions and how they might relate to their learners' cognitive flexibility.

CHAPTER 6 – PERCEPTIONS AND ATTITUDES REGARDING COGNITIVE COMPETENCIES IN RWANDA (RQ3)

International research on children's cognitive flexibility typically uses quantitative methods to examine its development in relation to other mental processes and wider background or environmental factors. Few, if any, studies have adopted more *qualitative* approaches, perhaps because 'cognitive flexibility' and 'executive function' are psychological terms and little known or used in everyday contexts and even many school settings. Nevertheless, the beliefs, attitudes and values that teachers and other educationalists hold may have material and direct impacts on these important aspects of their learners' development.

Previous chapters in this study examined the measurement of Rwandan pupils' cognitive flexibility and its association with household factors and other learning outcomes. As *post-positivist* research, however, this chapter now complements those analyses by turning attention to the personal perspectives of school staff and specifically the thoughts and opinions that drive their behaviours inside the classroom. In particular, it draws on data from interviews with Rwandan teachers to answer the third research question (RQ3) which asks "What are the perceptions and attitudes of Rwandan public primary school teaching staff regarding the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?"

To understand these perspectives, the first section maps out the analytical approach taken to address RQ3, including the various processes to transcribe, translate and code the qualitative data. The second section provides a detailed overview of the different respondents, while the third section explores Rwandan perceptions of creativity, innovation and problem solving as three key skills that draw upon and relate closely to children's cognitive flexibility. The fourth section examines the relevance of such competencies among diverse types of learners, and the fifth section closes the chapter with a discussion on the findings.

6.1 Analytical Approach

As described in Chapter 3, the interviews comprised semi-structured conversations with 16 head and class teachers from four public primary schools in Kigali. In each case, the respondents received prior information regarding the purpose of the research and were invited to share their views and accounts of lived experiences in Rwandan classrooms [44]. Of most relevance to RQ3, teachers were specifically asked about their perceptions and opinions relating to the development of their pupils' skills for adapting to life in the rapidly changing world.

To help operationalise these ideas, I used three Kinyarwanda terms as related proxies to explore the teachers' different perspectives, not least given their likely unfamiliarity with 'cognitive flexibility' as a predominantly Western psychological construct. Indeed, these expressions were chosen in discussion with my supervisor at the University of Rwanda and colleagues from Laterite Africa, which ensured that they were culturally relevant, conceptually appropriate and in keeping with the purpose and objectives of the research. As indicated in section 3.6.1, I asked teachers about their beliefs and attitudes concerning children's '*guhanga udushya*' (creativity), '*ubudasa*' (innovation, or literally 'something different') and '*kwishakira ibisubizo*' (problem solving), being terms initially used in political discourse but more recently included as 'generic competences' in the revised Rwandan curriculum (REB & MINEDUC, 2015).

On average, the conversations lasted 40 minutes, the duration of a class period in Rwandan public primary schools. The interviews were conducted in a mix of English and Kinyarwanda and facilitated with the support of a bilingual translator. All but one teacher agreed to be audio-recorded so I took detailed notes of her responses and prepared a narrative overview of the key points afterwards. For the remaining participants, however, I needed to transcribe the interviews as a first step in their qualitative analysis.

6.1.1 Interview Transcription

Section 3.6.1 above highlighted some of the practical and methodological issues associated with using a translator. Likewise, transcription is arguably not a straightforward, mechanical or neutral process of transformation from audio to written media, but involves a series of important judgments and decisions (Brinkmann & Kvale, 2015). The choice of which

[44] Before each interview, teachers were provided with information sheets and consent forms, in both English and Kinyarwanda, which detailed the aims of the study and highlighted my interest in these skills. Given the many challenges Rwandan teachers typically face, from large class sizes to resource constraints, I questioned whether they would have had much prior opportunity to consider these competencies in any great depth and so wanted to allow them at least a brief period for reflection ahead of the interviews.

responses to record and how can have significant implications for how participants are represented, data are analysed and conclusions are drawn (Oliver et al., 2005).

The main issue concerns the degree to which the transcription aims to capture all aspects of the communication, both verbal and non-verbal. At one end of the spectrum, naturalised and verbatim transcriptions typically seek to include every pause, gesture and response token, such as ‘hmm’ or ‘ahh’, and are often used in conversational or linguistic analyses (Bazeley & Jackson, 2013; Esterberg, 2002; Richards, 2015). However, such records are particularly time-consuming to produce and some critics question whether any transcript can ever truly capture *all* of the nuances and subtleties of interview interactions (Kvale, 1996; Mason, 2002).

At the other end of the spectrum, transcription may entail cleaning up participants’ responses into a more formalised written style or narrative summary (Brinkmann & Kvale, 2015; Riessman, 2002). This approach takes less time and may be more appropriate for research focused on the *informational content* of interview discussions, but such transcripts risk losing authenticity as a result of decisions on which responses to include and emphasise, and which to omit (Denscombe, 2017; King & Horrocks, 2010; Oliver et al., 2005). Indeed, there is an argument that transcription always involves some level of interpretation and researchers should be explicit and reflexive about the ‘ontological and epistemological baggage’ they bring to the process (Holstein & Gubrium, 2003).

In the present study, I sought to strike a balance between these two contrasting approaches to transcription. Given the underlying post-positivist paradigm, I was conscious that my understanding of the teachers’ responses as both interviewer and transcriber would be shaped by my own cultural-linguistic filters and positionality, as discussed in section 3.7.4 (Oliver et al., 2005). Furthermore, the participants’ answers had already been interpreted, redacted and summarised by the translator before I heard them in English, and so had undergone an additional stage of social construction and co-creation.

To minimise any further dilution or distortion, I therefore transcribed the English content largely verbatim, using naturalised speech and noting where the teacher or translator changed languages or the responses were inaudible. However, in light of time pressures and my intention to use thematic rather than conversational or discourse analysis, I did not record every pause, repetition or response token, not least because they typically derived from the *translator's* language rather than that of the interviewee[45]. At the end of the transcriptions, I listened to a selection of interviews again to confirm the accuracy of the records and to correct any errors or deviations.

Undertaking interviews and transcription across multiple languages nevertheless entails increased risks that participants' responses will be misheard, misinterpreted or misreported. To address these risks, I conducted three further checks to ensure that the translations and transcriptions were accurate and reliable.

6.1.2 Translation Checks

During the interviews, there were several instances where the teachers would provide long and detailed answers but without pausing to give the interpreter adequate time to translate their responses. As indicated in section 3.7.4, it would have been impolite and culturally inappropriate for the translator to interrupt their responses, particularly where the teacher was older and senior to him. In which case, we arranged for a second round of translation whereby the interpreter would listen to each interview again, review the verbatim transcripts and make any necessary amendments to ensure the accuracy of the translation[46].

However, both the preliminary and later stages of the translation involved the same interpreter, which could simply reinforce any personal bias in his translations. I therefore engaged a second independent bilingual interpreter to review and opine on the quality of the initial interview translations. As with the main interpreter, the second translator was required to sign a non-disclosure agreement, which set out her duties of confidentiality and anonymity regarding the participants' contributions. She then listened to an interview from each of the four schools and each of the different teacher categories, comparing the original responses in Kinyarwanda to the preliminary translations and subsequent transcriptions. Overall, the interpreter reported that the translations were of good quality and accurately captured the content and meaning of the teachers' responses.

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[45] One participant chose to respond primarily in English, in which case, I recorded a greater number of his language characteristics to maximise the accuracy of his interview transcription.

[46] To achieve this, I shared the audio files and anonymised transcripts with the interpreter via the University of Cambridge's OneDrive platform. This secure service encrypts the data and uses storage centres located in the United Kingdom, not least given the study's funding requirements and the relevant exemptions of the GDPR. All files and transcripts were then deleted immediately following completion of the review.

As a final step, I shared the reviewed and edited transcripts with the participants for any comments, embellishments or clarifications (Shopes, 2011). A few of the teachers replied, but none of them to explicitly challenge or confirm their responses in the interviews. This was unsurprising and could be explained by one or more factors, not least their limited access to email, language issues, time pressures, perceived differences in positionality, or indeed because the transcripts accurately reflected their views and perspectives.

6.1.3 Thematic Coding and Analysis

With the interviews transcripts checked and finalised, I used the thematic analysis framework outlined by Braun and Clarke (2006) to examine teachers' perceptions and attitudes, and thereby answer RQ3. Overall, I took an exploratory approach towards the dataset, not least given the seeming lack of prior qualitative research on children's cognitive flexibility development and, as a result, the unavailability of any established literature or schedules to inform the coding of participants' responses. Similarly, the use of an interpreter to convey the teachers' perspectives in English meant that I was more interested in the substantive content of their answers rather than the specific words they chose in Kinyarwanda.

Thematic analysis offered several key benefits in this respect. First, it provides considerable practical and theoretical flexibility to achieve a rich and complex account of the significant data, and across a range of philosophical and epistemological positions (Braun & Clarke, 2006). Second, thematic analysis allows for more inductive, immersive and open approaches to coding which are grounded in the actual data themselves and which cast a wide net to include any responses that could be relevant, where the codes are "tags or labels for assigning units of meaning to the descriptive or inferential information compiled in a study" (Miles & Huberman, 1994, p. 56). Third, it aligns with the post-positivist tradition by emphasising the active role of the researcher in identifying particular patterns and themes, in contrast to more passive descriptions of analysis where trends are 'discovered' or 'emerge' more organically from the dataset (Taylor & Ussher, 2001). Finally, thematic analysis enables data to be evaluated at different levels, either semantic or latent. In the current study, I focused primarily on the former and the explicit meanings of participants' responses to distinguish different patterns, not least given queries concerning Rwandan teachers' likely familiarity with theories on children's cognitive development.

In light of these advantages, I followed the six-step approach to thematic analysis summarised by Braun and Clark (2006) to code and interpret the interview transcripts in NVivo 12. During the first stage, I familiarised myself with the dataset through immersive and repeated reading of the transcripts to start to search for potential trends or patterns of response. Already, I had a fairly detailed knowledge of the interview content having transcribed the conversations myself, and so this stage largely comprised a deepening of that understanding and a re-familiarisation with the teachers' views and perspectives, rather than coming to the data afresh.

Next, I worked through the entire dataset systematically, moving back and forth to develop initial codes through which to structure the content into meaningful groups. In this respect, I was able to draw on notes and observations recorded during the transcription process regarding certain repeated responses or the possible reasons that might underlie participants' particular answers.

During the third phase, I examined the codes to organise them into broader categories and themes, where a "theme captures something important about the data in relation to the research question, and represents some level of *patterned* response or meaning within the data set" (Braun & Clarke, 2006, p. 82, original italics). Identification of the themes was often related to, but not solely dependent on, the frequency with which the participants mentioned or discussed the relevant issue, and this process was aided by the semi-structured nature of the interviews including the use of similar, if not identical, opening questions for all respondents. As a result, certain codes could be grouped according to the relevant interview question, although there were also numerous themes that cut across different sections of the discussions. For example, it became quickly apparent that teachers' understandings of the specific competencies were often inextricably related to the perceived benefits of learners developing those particular skills.

In the fourth stage, I reviewed and refined the themes based on the internal coherence of their coded data, as well as the clarity of the distinctions between them (Braun & Clarke, 2006). Specifically, I read the collated excerpts for individual themes to ascertain whether they comprised an integral whole, then I considered the validity of each theme in relation to the whole dataset and other themes to check whether they accurately mapped the teachers' interview responses. During the fifth phase, I further refined, defined and named the themes, identifying their individual 'essence' and their relevance to RQ3. In some cases, the themes were updated or combined where they offered limited additional insight as initially framed. For example, one theme concerning teachers' vocation and the associated codes regarding their professional commitment and personal satisfaction were collapsed into other themes around the benefits of learning, given teachers' roles in achieving these aims. Appendix 14 sets out a table of the final themes, codes and sub-codes used throughout the process and in the sixth stage, which comprised producing a report on the qualitative research findings.

Throughout the analysis, I also examined the content of participants' responses with reference to their different individual characteristics. In particular, I used case classifications in NVivo to record whether the respondent was male or female, a class or head teacher, and his or her years of prior professional experience. Most importantly for the *multi-school* case study, I noted the school at which the participant worked, not least to enable the identification of differences between the various teachers' responses (Cohen et al., 2015; Merriam & Tidsell, 2016).

Adopting a systematic approach to qualitative analysis, such as that proposed by Braun and Clarke (2006), conferred important benefits in terms of methodological rigour and robustness. Indeed, many of the steps described above, not least the multiple translation checks, were included to ensure and maximise the validity and reliability of the qualitative data findings.

6.1.4 Validity and Reliability

Using thematic analysis and more inductive approaches to interview coding nevertheless entails certain risks, not least concerning the authenticity, credibility and trustworthiness of the data. In addition to the issues described in section 3.4.3 above, Cohen et al. (2015) suggest that interviews can be particularly affected by prejudices deriving from the assumptions and prior experiences of the researcher, "the characteristics of the respondent and the substantive content of the questions" (p. 204). As inherently social interactions, interviews can also give rise to confirmation bias, and so researchers must be wary of interpretations that simply corroborate their own predispositions and preconceptions.

In the present study, such assumptions had been largely shaped by my previous experiences of working and conducting research in Rwanda, as outlined in Chapter 1. Particularly, the latter study undertaken in 2012 entailed an exploration of stakeholders' perceptions of learners' cognitive skills, including their creativity and problem solving, and involved asking several interview questions similar to those used to address RQ3 (Bayley, 2015). Despite differences in the *type* of respondent, education advisers and international NGO representatives in the 2012 research compared with primary school teachers in the current study, I therefore had some pre-existing expectations about participants' likely replies and possible trends that may arise from analysing their transcripts. Indeed, a few of the 2012 interviewees had themselves previously worked as teachers in Rwandan schools and so some overlap in attitudes and perspectives between the two studies was probably inevitable. Nevertheless, my awareness of these preconceptions meant that I took an open, grounded and inductive approach to the coding to minimise their influence and to ensure that the resultant themes accurately reflected the 2018 responses, and not the 2012 interviews.

More broadly, understanding validity and reliability in the context of *qualitative* research requires thinking beyond the issues of generalisability and replicability commonly emphasised in quantitative studies. Regarding validity, studies must ensure authenticity by demonstrating that the findings represent the relevant phenomenon fairly, fully and accurately, and display trustworthiness with transparent accounts of steps taken to establish credibility and objectivity. Similarly, they must provide a 'thick' description of the context for readers to assess *themselves* the transferability and generalisability of the results to their own specific setting (Cohen et al., 2015; Miles & Huberman, 1994).

Numerous sections above have highlighted the different approaches taken to maximise the validity of the interview data. These included consultation with Rwandan stakeholders and policymakers to frame the focus of the study, trialling the interview schedule with teachers in the first pilot school, sharing interview transcripts with respondents by way of 'member checking', and triangulating the research by using multiple methods, namely interviews and observations, as discussed further in Chapter 7 (Merriam & Tidsell, 2016).

Regarding reliability, I used two code-checking processes to assure the dependability and stability of the qualitative data, and the inductive coding in particular (Miles & Huberman, 1994). First, I recoded the responses to the four interview questions relating to RQ3 over a week after the initial coding to measure the internal consistency and *intra*coder reliability of my approach. Using the comparison function in NVivo revealed an agreement of 99.30 per cent and a Cohen's kappa of .85, the latter being a more conservative indicator of reliability by correcting for the probability that some agreement will occur by chance (O'Connor & Joffe, 2020). Second, I worked with an independent checker who recoded the responses from ten randomly selected interviews to thereby ascertain the level of *inter*coder reliability. This process achieved 98.84 per cent agreement and a kappa of .66, and overall both checks showed a substantial if not high level of coding reliability (Miles & Huberman, 1994; O'Connor & Joffe, 2020).

In summary, the present study has employed numerous approaches to establish the validity and reliability of the research findings. Before turning to the substance of those findings, however, the next section examines the profile of the respondents in greater detail.

6.2 Overview of Respondents

Teachers' perceptions and attitudes regarding child development may be shaped by a host of personal and professional factors. Table 3.3 above provided a summary of certain respondent characteristics, specifically their gender, class grade and subject taught. Table 6.1 below builds on that breakdown to include further information on the individual teachers, in particular any other subjects taught and their recent participation in any professional training. However, teachers' years of experience have been banded and details of the specific schools they work in omitted to protect the confidentiality and anonymity of their responses.

Regarding subject and class, most interviewees reported teaching multiple subjects, a combination of grades or a mixture of the two. For example, several Primary 1 teachers indicated that they also taught children in Primary 2, while various Primary 4 respondents had additional classes scheduled with learners in either Primary 3 or Primary 5. Teachers of fewer subjects typically taught pupils across multiple grades or several classes within the same cohort, depending on the size of the school. One school for instance had 12 separate classes for each of Primary 1 and Primary 4 and, because of double-shifting, six classes for each grade running in parallel at any one time.

Table 6.1 - Overview of Teacher Respondents including Experience and Training

Class Grade	Subject(s)	Gender	Years as Teacher (Head)	Years at School	Training(s) Received in Past Year
Head Teacher		Female	15+ (6-10)	15+	4 weekly CBC trainings on Saturdays in own school by SBM on lesson planning and teaching methodologies
		Female	15+ (6-10)	6-10	1 day training by REB outside the school; CBC trainings 2 times per week in the school by trained teachers from the school
		Female	6-10 (6-10)	0-5	1 training by VSO over 3 days on school management and data collection
		Male	15+ (15+)	6-10	2 trainings comprising 1 day on CBC and learner-centred methods by REB and 1 day on preparing strategic and action plans by Wellspring
Primary 1	English, Drawing and Music	Female	6-10	0-5	2 trainings on CBC over a total of 7 days in own school by SBM on lesson planning
	English	Female	11-15	11-15	Ongoing CBC training by other teachers in own school every Tuesday and Friday; external training for 2 days on teaching religion
	English and Social Studies	Female	6-10	0-5	2 trainings on CBC comprising 2 weeks and 1 day on using the new teaching methods by teachers in another school and Wellspring (organised by subject)
	English and Mathematics	Female	6-10	6-10	CBC training for 2 weeks by REB outside the school, 1 day on English and 1 day on mathematics by Building Learning Foundations and ongoing support from Wellspring based on needs assessment
Primary 4	Mathematics and French	Female	15+	15+	CBC training weekly (Saturdays) by SBM in own school on teaching methodologies, including digital learning and Bloom's Taxonomy
	Mathematics	Female	15+	15+	3 trainings on CBC comprising 1 week, 2 days and 1 day by teachers in another school on lesson planning, behaviour management, critical thinking and values
	Mathematics, English and French	Male	6-10	0-5	Termly with Wellspring, monthly with the sector, weekly follow-up from Wellspring; CBC training on topics including assessment for 9 days in Rwamagana and ICT training for 1 week both by REB
	Mathematics, Social Studies, French and Sports	Female	11-15	11-15	3 trainings on CBC regarding preparing courses and cross-cutting issues such as gender, critical thinking and communications for a total of 4 weeks and 4 days by teachers from own school trained by REB; One Laptop Per Child training every morning for a month by teachers from own school trained by REB
	Social Studies, Religious Studies, Science and Technology	Male	6-10	0-5	2 trainings on CBC over 4 Saturdays in own school by SBM and IEE on lesson planning, cross-cutting issues, generic competencies, evaluating, using teaching and learning materials; 2 days external training by the REB; 5 days external training on English and using learning materials by Building Learning Foundations
	Social Studies and Science	Female	6-10	0-5	1 training on CBC for 1 week by REB in Nyanza; 1 training on mentorship for 3 weeks by the University of Hertford in Rwamagana
	Social Studies, Science and ICT	Male	6-10	6-10	3 trainings on ICT lasting 2 weeks and 1 week and 3 trainings on CBC lasting 2 days each both by REB, 2 trainings on English lasting 1 week by Wellspring, all at external locations
	Social Studies and English	Male	11-15	0-5	2 CBC trainings for 3 weeks and 1 week by REB in multiple locations on teaching knowledge and skills; online training for 1 year by KIE; training with Wellspring 6-9 times a year

Source: Primary data, 2018. Notes: CBC = Competence-based Curriculum; IEE = Inspire, Educate and Empower Rwanda; KIE = Kigali Institute of Education; SBM = School-based Mentor; VSO = Voluntary Services Overseas.

In terms of age and experience, the respondents ranged from those in their 20s to others likely to be nearing the end of their careers. They reported working as teachers for between 6 and 40 years, with the vast majority of class teachers holding less than 15 years' experience and nearly all of the principals having worked in the profession for at least 20 years[47]. Of particular note, none of the teachers in the sample were very new or recently qualified which could reflect wider patterns of national teacher deployment or the relatively high cost for young teachers to live and work in Kigali.

Respondents were further asked about any training sessions they had participated in over the preceding 12 months. Nearly all interviewees referred to some formal training on implementing the competence-based curriculum in their classrooms but the extent, depth and modality varied between teachers, even within the same school. Some of the respondents had undertaken several weeks of instruction by the Rwanda Education Board (REB) in external venues, covering topics including lesson planning, learner-centred methods and the use of technology within their classes. Meanwhile, other teachers reported joining occasional standalone sessions conducted by the REB or by teachers from other schools who had themselves received the direct REB training.

Within schools, the respondents described a mixture of practices. Teachers in one school, for example, consistently reported a formal programme of weekly training by the school-based mentor to enhance their use of learning aids and understanding of different cross-cutting issues. Other interviewees mentioned receiving ad hoc or even more regular instruction from teachers in their school who had participated in the REB training sessions. Indeed, a few of the respondents described themselves as school subject leaders or ‘multipliers’ with specific responsibility for coaching colleagues, over and above their own teaching workloads. Further details concerning schools’ different approaches to foster teacher collaboration are set out in Chapter 7 below.

In addition to capacity within schools, around half of the interviewees discussed receiving support from one or more external organisations or international NGOs. Teachers in two of the schools specifically referred to guidance and training from the Wellspring Foundation, while other respondents also mentioned sessions conducted by Voluntary Services Overseas (VSO) and the Building Learning Foundations programme. Finally, a few teachers discussed taking steps to strengthen their skills or content knowledge *outside* their formal school

[47] The timelines for some of the older interviewees were not straightforward or linear, not least given the history of instability and migration in the region.

responsibilities or subject areas, in seemingly proactive initiatives to enhance their professional capabilities and expertise.

With details of the respondents now set out, the following sections turn to the findings of the qualitative data, and the perceptions and beliefs that teachers hold about the development of their learners' cognitive competencies.

6.3 Perceptions of Cognitive Competencies

During each interview, the teachers were asked about their understanding of '*guhanga udushya*' (creativity), '*ubudasa*' (innovation) and '*kwishakira ibisubizo*' (problem solving), and why they thought such skills had been included in the competence-based curriculum. At the end of the interviews, we also requested the respondents' views on why schooling was worthwhile and their pupils' learning was important to them. Overall, I was interested in how the participants formulated the purposes of education in Rwanda, and how the development of children's cognitive competencies related to those objectives.

The teachers typically adopted one of two approaches to answer the initial questions. Numerous interviewees described their perceptions of the competencies one by one, but the majority outlined their more holistic impressions of the three skills combined. Several teachers also framed the competencies in relation to themselves and their own classroom teaching practices, such as the use of innovative learning aids or methodologies in their lessons.

Across the responses, I discerned two emerging themes as the individual and collective benefits of cognitive competencies specifically and formal education more broadly. In general, the interviewees described the value of creativity, innovation and problem solving for everyday Rwandan life: "…we teach children to be able to do things, things that can solve problems in real life" (Male Primary 4 teacher). However, some participants also emphasised their potential contribution towards wider societal and national development: "…teaching children is the best you can do because if a country has educated people, that means development" (Female Primary 4 teacher). Conversely, most teachers discussed the role of schooling generally to foster responsible citizenship within the community, but several respondents also highlighted its importance for improving practical skills at the individual and household levels. In which case, the findings below regarding interviewees' perceptions of cognitive competencies are grouped according to these two broad themes.

6.3.1 Practical Benefits for Individuals

For all of the teachers, learners' cognitive competencies and specifically their creativity, innovation and problem-solving skills appeared to confer significant practical benefits for everyday private life. Many participants understood them as key capabilities that enable individuals to translate their learning from the classroom into constructive action in the real world. As one respondent explained:

> what we do is make sure that children can relate the lesson that they are learning with their everyday life…so that when they walk outside the school, outside the classroom, they can be able to implement what they have learnt in class (Female head teacher).

The 'practical' nature of such skills also has particular connotations in addition to its real-world application and relevance. First, numerous teachers contrasted pupils' practical learning under the competence-based syllabus with the more knowledge-based, content-focused and theoretical approaches to education emphasised in the previous Rwandan curriculum. One participant indicated that "[c]hildren of the past were only learning theories without a concrete understanding of where things come from, but today children they learn in practice, so the practical things are much more compared to the theory" (Male Primary 4 teacher). Second, a few of the interviewees suggested that creativity, innovation and problem solving are also 'practical' in the sense that they can be actively practised and thereby improved with each new use.

Beyond pupils' cognitive competencies, the teachers provided several examples of how education *in general* was being made more relevant for Rwandan daily life. Some of them, for instance, discussed the value of children learning to weave mats or repair items of clothing, while others referred to the use of nutrition lessons in school to help improve families' diets at home. The most common example cited, however, concerned pupils' ability to link principles of geometry with the measurement of spaces and items in the real world:

> we have learnt about measuring squares and rectangles. A pupil has to be able to go home and…measure his parents' plot of land and say 'This land is this big and, you know, because I learnt this in classroom'. So they, the pupils don't only have to know things in theory but they also have to know how to put them in practice (Male Primary 4 teacher).

In addition to these more generic benefits of practical education for individuals, my analysis also identified three further sub-themes among the participants' responses, in each case being even more closely related to private individuals' creativity, innovation and problem solving. These concerned learning for originality and taking initiative, for self-reliance and independence, and for adaptable incomes and resilient livelihoods.

Originality and Initiative

According to the teachers' responses, '*guhanga udushya*' and '*ubudasa*' translate in their simplest terms as 'creativity' and 'innovation' respectively. In each case, they entail a sense of originality, generating something new oneself, being unique, or doing things in a different but good and possibly even better way. One participant framed *guhanga udushya* with reference to both classroom learning and wider societal trends:

> [i]t's just about coming up with new things that you either bring in the culture, or things you create which were not existing before but things you create because you received a lesson or because you were taught something. So for example, we have seen that some young Rwandans today, they're coming up with new products or new things, in ICT, in arts and crafts (Female head teacher).

Several interviewees further elaborated their understandings of 'creativity' and 'innovation' by indicating explicitly what they were not. They contrasted the competencies with using ideas and content memorised from books, copied from the blackboard or learnt from someone else. One Primary 1 teacher also explained that current classroom practices differed from how she had studied and grown up, which afforded little space for children to be or at least *feel* creative.

Regarding learners' educational experiences, numerous respondents described the role of creativity and innovation in schools to encourage pupils to take the initiative and to give them a forum to be enterprising, inquisitive and proactive. They referred to empowering the children to use their innate capabilities, nurturing them to become creative entrepreneurs and the importance of education to foster learners to have open and curious minds: "today a teacher doesn't think for children anymore, for pupils anymore. They give them a platform to observe, to explore" (Female Primary 4 teacher). Similarly, teachers can find a space to express and develop their own creativity and innovation in their classroom practices:

> by *guhanga udushya* I understand that it's, I'm given an opportunity to bring creativity in my classroom and not necessarily what I find in the curriculum but…I can bring up new things in the classroom to help students learn better. And by *ubudasa*, I understand that…it's all about the differences…I have to be unique (Female Primary 1 teacher).

Building on this sense of originality and initiative, most teachers further discussed the role of cognitive competencies to encourage learners' self-reliance, independence and autonomy, with particular reference to their development of *kwishakira ibisubizo* or problem solving.

Self-reliance and Independence

As described above, the majority of interviewees saw value in nurturing creativity and innovation to enable people to think more originally and with an open mind, not simply repeating the content of lessons or copying the behaviour of others. Over half of the respondents also reported that such cognitive competencies went further, emboldening learners as children and then adults to enact deliberate changes in their individual lives. Indeed, as the teachers explained their perceptions of problem solving or *kwishakira ibisubizo*, many of them emphasised the importance of pupils learning to take action and responsibility to face challenges *on their own*, and of becoming self-reliant and self-sufficient to solve problems without dependence on the support of others.

For example, one participant suggested that the Rwandan government had included such competencies as problem solving in the new curriculum because "they wanted children to be able to develop things on their own, to do things on their own, not giving, putting things into them, into their heads but having them create, and learn by practising" (Female Primary 4 teacher). Similarly, another respondent understood *kwishakira ibisubizo* as meaning that:

> …we have to come up with solutions ourselves without waiting or expecting anything from anyone else. For example, we have to teach children that from their creativity they can create solutions to their challenges and we also have to remove from their mind sets waiting for donations from other people (Male Primary 4 teacher).

Within the classroom, several interviewees described efforts to foster independence among their pupils by acting more as a guide than an instructor, and by giving the children adequate time to do activities and exercises themselves without providing unsolicited assistance. However, over half of the participants also highlighted the importance of learners' cognitive competencies, their creativity and problem-solving skills, when they leave school and enter the workforce.

Adaptable Incomes and Resilient Livelihoods

For the majority of respondents, the development of children's cognitive skills, their *guhanga udushya*, *ubudasa* and *kwishakira ibisubizo*, was critical for their future prospects on the Rwandan job market. Specifically, they discussed their relevance for school leavers to be able to earn money and generate income to meet their basic needs, such as food and clothing. The teachers further suggested that these skills aided pupils to learn to be productive, and not just competent but also competitive when looking for work.

Numerous participants similarly mentioned the value of children building such practical skills outside the school in parallel with their formal education. This could include supporting their parents with their own livelihoods whether through farming or the running of small shops. Some also highlighted the role of schooling to nurture flexible and resilient adults who can adjust to wider societal changes, on the labour market or otherwise:

> It's mainly to help them get educated, also to be able to adapt in any type of environment, life environment that they find themselves in, because you know life has different circumstances. They can be living in another country in the

> future so learning is very important because it will help them adapt to different situations or different contexts in life (Female Primary 1 teacher).

In addition to finding and maintaining employment, several teachers emphasised the need for school leavers and graduates to combine originality and self-reliance to *create* jobs and establish their own small businesses. They provided examples of rearing livestock or producing goods like shoes, bags or belts for sale. A couple of interviewees also referred to the government's 'Made in Rwanda' brand and policy to ensure more enabling conditions for small and medium-sized enterprises (Republic of Rwanda Ministry of Trade and Industry, 2017). Various participants further suggested that such entrepreneurship would be of increasing importance as more Rwandans complete their basic education:

> …it's been quite some time pupils finished high school…expecting that the government, there are jobs, government jobs, but today there are so many people who finish and the government can't provide jobs for every high school or every university student. So should that student stay at home and relax and say 'The government can't give me a job so I'm going to stay home'? No…a high school student can finish their school and then they will now make something, a business from their learning, from the courses they've taken at school (Female head teacher).

As outlined above, the respondents discussed a range of ways in which children's cognitive competencies, in particular their creativity, innovation and problem solving, seemingly further the wider purposes of education and confer benefits for individual learners' private lives. However, above and beyond this *micro* level, they also described the advantages that such skills appear to offer at the macro level of broader Rwandan society.

6.3.2 Collective Benefits for Rwandan Society

Governance structures in Rwanda are generally organised according to a four-tier hierarchy: below the national level, 30 districts (*akarere*) which are themselves subdivided into sectors (*umurenge*), cells (*utugari*) and villages (*umudugudu*). The teachers' responses nevertheless identified potential benefits arising from cognitive competencies and wider formal education that cut across these multiple social levels and indeed the full spectrum of collective Rwandan interactions.

For example, the interviewees talked about how practical skills could affect relations between individuals, within families and inside school classrooms. They also discussed how they could shape and inform people's behaviours and engagements within their local communities. Notwithstanding the multiplicity of these different levels, however, the participants described the collective benefits of cognitive competencies and children's learning with reference to two general sub-themes: responsible citizenship and nation building for the future.

Responsible Citizenship

Nearly all the teachers interviewed in the study discussed the importance of education and, to a certain extent, learners' cognitive competencies for creating responsible members of Rwandan society. Some, for example, mentioned the value of civic aspects of schooling for children to assimilate into their communities and to learn how to live together as reliable citizens. As one participant explained:

> When a child is born, they come in our society, in our community, so it's our obligation, it's our duty to teach that new-born, that child, how to live and how [to] get used to the community, teach them how they will live, their life in the community (Male Primary 4 teacher).

Specifically, many of the respondents described the role of schooling to inculcate an understanding of acceptable cultural values and behaviours in its pupils. They referred to the importance of politeness, discipline and respect, whether for teachers, parents or school rules. One interviewee also mentioned the need for children to learn key components of Rwanda's national history, not least facts relating to the 1994 genocide, while another recounted an instance of recent prosocial behaviour by his pupils:

> …there has been one student who lost their parent and the students came up with an idea by themselves to contribute one coin and then they decided to go pay a visit to this student who had lost a parent and they came to the head teacher like

> 'We are going to visit our friend and we made a contribution' (Male head teacher).

Numerous participants further illustrated the importance of acceptable conduct and responsible citizenship by describing examples of *un*acceptable behaviours in Rwandan society. For instance, some of them discussed such social ills as crime, drugs and alcohol abuse, suggesting that uneducated people were more likely to partake in these wayward activities. Others referred explicitly to the threat of ignorance, which they saw as undermining national progress, but which could be overcome through education and learning.

Nation Building for the Future

Indeed, in addition to learning for responsible citizenship, most of the respondents also highlighted the role of education in Rwanda's national development for a better future. They described the need for an educated population and workforce to participate in the growth and progress of the country. A couple of teachers similarly recalled President Paul Kagame's public use of the terms '*ubudasa*' and '*kwishakira ibisubizo*' to emphasise the innovation, problem solving and self-reliance that every Rwandan citizen can contribute towards the country's improvement.

Regarding the *nature* of Rwanda's development, nearly all of the interviewees described activities that supported the country's domestic growth within its own borders. However, one respondent also referred to Rwanda's growing regional and international profile: "…Rwanda is becoming global, is you know integrating with so many other economic regions and other countries so I would say that Rwanda is becoming bigger now" (Male Primary 4 teacher). Likewise, most of the participants discussed the importance of education for national development in generic terms, but the same teacher highlighted its particular relevance in the Rwandan historical context: "The genocide was beyond imagination so we have to make sure that our children, the future generations, do not make a similar mistake" (Male Primary 4 teacher).

Many interviewees indeed conveyed their own sense of personal commitment, responsibility and dedication to pursuing this objective of national development. Several referred to a ‘professional conscience’ or described teaching as their way of ‘giving back’ to the community. As one respondent explained:

> It’s all about country building. So we are building the country here. For example, today we are the main people, we are the main country builders today but tomorrow these children, these pupils will be the ones taking over. So we have to get them prepared, we have to get them ready to take up that difficult responsibility (Female head teacher).

In summary, the Rwandan teachers interviewed highlighted a mix of individual and collective benefits that they associated with learners’ cognitive competencies, specifically their creativity, innovation and problem solving, and education more generally. They described the value of originality and self-reliance to support practical changes in people’s everyday lives, whether relating to their livelihoods or otherwise. Similarly, they emphasised the importance of learning to create citizens of the future who will be responsible for the country’s progress and development.

However, within Rwanda, there are different types of learners who attend school in a range of diverse contexts. As discussed in section 2.1.2, some academics reject the idea of universal and transferable skills, and instead stress the significance of political, cultural or economic settings in their construction, acquisition and application (Kraak et al., 2006; Tikly et al., 2003). In light of these debates, the interviews therefore explored the respondents’ attitudes on the relevance of these cognitive competencies among different pupils, as the next section explores.

6.4 Cognitive Competencies among Different Learners

Following questions about teachers’ perceptions of creativity, innovation and problem solving, and the value they ascribed to them, the interpreter and I then asked whether there might be any differences between such competencies for different types or categories of learners. Examples were given of girls and boys, and pupils learning in both urban and rural contexts.

6.4.1 Similarities between Learners

Overall, the majority of interviewees responded that there were no differences between the competencies for diverse groups of children. Regarding the development and acquisition of such skills, participants indicated that all Rwandan pupils learn the same content using the same competence-based curriculum.

In terms of gender, the teachers were even more emphatic that there was no difference between the learners. They explained that both boys and girls can do the same things and referred to the fact that they learn side by side to justify their position. As one interviewee explained: "The reason why they are the same is…they all learn together. If they were, if these values had different importance, we'd be splitting them in different groups" (Male Primary 4 teacher).

Several respondents went beyond gender to describe other ways in which the competencies were similar despite differences between pupils. For example, they highlighted the situation of children with special educational needs and the importance of attending to their particular requirements: "…we have an inclusive learning environment, either be it a girl or a boy or a child with a disability, they all have to find a place in the classroom" (Female head teacher). Numerous participants also discussed perceived differences in pupils' learning aptitudes. One head teacher explained that the introduction of the competence-based curriculum had prompted him to think more holistically about the multiple aspects of children's development:

> …another thing…that this CBC [competence-based curriculum] has brought to light is…the bad language that we used to use in the past which said 'This child is very smart' and 'This one is not smart', so things have changed. There is no smart child, there is no dumb child, they just have different learning capabilities (Male head teacher).

Many respondents also argued that the development of pupils' cognitive competencies was nurtured equally regardless of their context or environmental setting. They reiterated that schools across the country used the same competence-based curriculum to foster learners' skills irrespective of their location, with one interviewee clarifying that: "A child from the city is a Rwandan child and a child from the rural area is a Rwandan child, and when the government is preparing the programme, only one programme gets created" (Female Primary 4 teacher).

Regarding the *application* of creativity, innovation and problem solving, eight of the 16 participants similarly believed that such skills were transferable between different contexts. They indicated that learners, whether children or adults, should be able to use the competencies effectively wherever they find themselves. For one respondent, this transferability was particularly important for people facing mobility, migration or changing life circumstances:

> And another point is that a pupil doesn't really know, a child doesn't know where they will live and settle. It can be either in a rural area or it can be in an urban area. So they have to adapt to wherever they are and they have to be productive to make something from the, any situation they are in (Male Primary 4 teacher).

In contrast to these views, however, four of the interviewees argued that learners' cognitive competencies and the processes that support their acquisition and development *are* different, with a further four acknowledging at least some difference depending on their context or local environment.

6.4.2 Differences between Learners

Within this group of minority views, there was considerable divergence regarding teachers' attitudes and opinions concerning the universality of pupils' cognitive competencies. Some perceived there to be differences in the delivery of education to nurture and foster skills like creativity, innovation and problem solving, while others saw diversity in how they would be used and applied in practice. In most cases, any difference was attributable to learners' location, whether they lived and attended school in rural or urban settings, and even several respondents who emphasised the equivalence of competencies between girls and boys, men and women, mentioned likely differences attributable to their environment.

Regarding the *attainment* of cognitive competencies, interviewees referred to both the cultural relevance of the context and teachers' use of learning aids, particularly ICT. For example, numerous participants referred to lessons on domestic animals, farming and agriculture, and described how much more accessible such content would be to pupils living in the countryside than those in cities. Similarly, and notwithstanding efforts to proliferate laptops and other computer hardware across schools and universities in Rwanda, numerous respondents highlighted ongoing differences in their availability and use depending on learners' locations (Mukama, 2010; Rubagiza et al., 2011). One interviewee explained his perspective on these issues as follows:

> …when I teach my students about agricultural tools here in the city they don't grasp that information or that knowledge quickly. They wonder like 'Why don't we see people farming? Where can we see these tools?' And another example in the rural area, teachers don't even have focus on ICT because it's very hard for a parent to afford a computer (Male Primary 4 teacher).

In addition to how children acquired and developed their cognitive competencies, several participants also argued that there are potential differences in the relevance, use and importance of such skills according to the geographic location. However, even among these respondents, there was divergence in opinion with some suggesting that creativity and innovation were more important for money-making activities in the city, while others indicated a greater need for job creation in rural areas. Nevertheless, some teachers once again emphasised the value of adapting such competencies to the particular context:

> For example, a child in a rural area can come up with an idea to make shoes out of banana leaves because that's what they see…a child in a rural area can come up with an idea of weaving mats, traditional mats we make in the countryside, whereas a child in the city can come up with a wooden table because that's what they see every day (Female Primary 1 teacher).

In summary, the teachers interviewed shared a mix of attitudes regarding the relevance of Rwandan pupils' cognitive skills. Without exception, they described equivalence between girls and boys, and some also noted the value of the competence-based curriculum to diversify notions of learning for more inclusive and sensitive practices in the classroom. However, opinions differed regarding the role and influence of environment and location, with half of the respondents reporting differences in teaching approaches and the application of competencies for pupils in the real world. By contrast, the other half referred to common teaching methodologies, including the use of ICT, in both urban and rural settings, and highlighted the importance of skill transferability as learners leave school and enter the labour market.

6.5 Discussion

This chapter has explored the various perceptions and attitudes that Rwandan teachers hold concerning the development of their pupils' cognitive competencies. Throughout the interviews, they emphasised the importance of more practical and relevant education and learning, whether this added value to individuals in their everyday private lives and productivity, or to the wider community and society through a stronger base of more reliable, responsible citizens.

Indeed, many of the responses echoed the language and sentiments of the new competence-based curriculum. For example, the majority of participants described the importance of learning to foster increased self-reliance and independence, both among children in the classroom and then as adults operating in society. This theme is particularly interesting in a context like Rwanda, which has relied heavily on international aid since the 1994 genocide, not least because it signals a deliberate and collective national shift towards greater self-sufficiency (Straus & Waldorf, 2011). By contrast, none of the interviewees explicitly mentioned qualifications, either as an outcome of their pupils' formal education or as necessary credentials for school leavers transitioning into the work force. Although the teachers were not asked any direct questions in this respect, the discussion regarding the general purposes and objectives of learning was framed in sufficiently broad terms to allow this issue to arise, if deemed appropriate by the respondents.

Several potential tensions also emerge from the replies of the different participants. The first concerns the balance between originality and culturally 'acceptable' behaviour. When describing their understanding of *guhanga udushya* and *ubudasa*, most interviewees referred to creativity, innovation and originality in doing something new, different and positive for themselves. Meanwhile, and as discussed in section 6.3.2, many teachers construed at least part of the importance of learning and formal education as the inculcation of Rwandan values about what is considered to be 'appropriate' behaviour. Through a certain lens, these two outcomes could present something of a tension, both in terms of the freedoms afforded for learners to be unique, and the balance between individual and collective preferences.

Of course, this conceivable tension is not particular to Rwanda but exists in many, if not all, countries around the world. Even the most visionary thinkers are still expected to comply with national laws and social mores. However, the prevalence of 'quality-of-life' rules, for example concerning personal hygiene or wearing shoes, is arguably more pronounced in Rwanda (Ingelaere, 2010; Longman, 2011; Thomson, 2018). Warner (2016) similarly describes an ambitious female student who was blocked from running as president for a school club because of her gender, and rebuked as being too "American", too liberated and un-Rwandan, notwithstanding the country's high proportion of women parliamentarians.

Overall, none of the interviewees mentioned or alluded to this supposed tension, in relation to their classrooms or otherwise. Whether or not they perceive the apparent balance between personal creativity, originality and uniqueness on one side, and adherence to collective norms on the other as competing or naturally coexisting within their social reality remains unknown. It could indeed rather represent the constraints of my limited comprehension of Rwandan culture and individualistic Western positionality to construe it as the former.

The second possible tension relates to the need for a national curriculum that promotes unity but also equips learners for practical skills to improve their everyday lives. This issue is most significantly pronounced in the diversity of teachers' opinions on the role and relevance of children's learning contexts. In this respect, the responses were fairly evenly split, with half of the participants denying any differences in the instruction and importance of cognitive competencies between urban and rural settings, and the other half acknowledging that there might be at least some variation according to the type of location.

In practical terms, this debate begs questions around the comparative merits of a single curriculum that reinforces a shared Rwandan identity and experience, versus more targeted and applied learning immediately relevant to people's lives. One interviewee, for example, noted the different challenges pupils face in rural and urban environments, and queried the use of teachers' *and children's* time spent "teaching ICT to people who will never touch a computer in their life" (Male Primary 4 teacher).

Similarly, although all of the respondents emphasised the equivalence of skills between male and female students, girls and boys, this does not mean that their learning journeys and experiences will necessarily be identical. Differences in household chores, which often weigh more heavily on girls and may include cleaning the home or caring for younger children could, on the one hand, increase their opportunities to develop practical competencies, but on the other hand, decrease time available for academic learning and homework to develop other important skills (Education Development Center, Inc., 2017; Howard et al., 2020; Thomson, 2018).

For now, however, the common curriculum arguably represents the best solution for basic Rwandan education. Any effort to differentiate learning by gender or location, such as limiting the instruction of ICT to pupils in urban schools, would necessarily exacerbate educational inequalities across the country, whereas learning focused on practical and transferable competencies should equip *all* individuals with the skills they need to overcome obstacles wherever they are.

Beyond its content and delivery, this curriculum-related tension also points at some broader issues at the *macro* level of Rwandan education planning. As outlined in section 2.3.1, the government continues to juggle the competing demands of poverty alleviation, national reconciliation and international competitiveness, each of which have different implications for learners' skills development and educational policymaking (Knutsson, 2012). Prioritising poverty reduction and social cohesion, for example, suggest a focus on achieving quality basic education for all, while emphasis on the latter arguably implies a need for greater tertiary investment. For the interviewees, however, the choice was largely clear and only one teacher mentioned Rwanda's more global economic aspirations. In a similar vein, Mukama (2009) argues that "it would be an illusion to pretend that students will be able to compete worldwide without being competent. Competence comes first and competition follows" (p. 53).

The final tension that emerges from the participants' responses likewise concerns macro level issues and specifically the different mechanisms through which pupils' cognitive competencies may contribute to Rwanda's national development. In particular, the teachers described skills for self-reliance, problem solving and responsible citizenship, but it was unclear from their accounts whether they viewed such competencies, and education more generally, as providing the basis for gradual and organic social growth, or as creating the conditions for more transformational national progress.

In this respect, qualitative research by Schuller, Brassett-Grundy, Green, Hammond and Preston (2002) among 145 adults in the United Kingdom drew distinctions not just between the personal and collective benefits of learning, similar to this study, but also the extent to which education can both sustain and transform individual and community lives. On the one hand, they explain that learning helps people to sustain themselves and mitigate personal risks, but also uphold the fabric of society by increasing understanding of different values and perspectives. On the other hand, education can facilitate individual change or collective transformation through improvements in community activism and political participation.

Viewing the teachers' responses through this additional lens, many of them referred to the role of education in national development, but without explicitly elaborating on whether it would take place through incremental processes to sustain the rebuilding of the country, its economy and social structures, or through more catalytic or radical routes of transformation. In the context, however, the former seems more likely, not least given the respondents' other comments on the importance of learning practical skills for enterprise, job creation and responsible citizenship.

In conclusion, the interviews with Rwandan teachers addressed RQ3 by yielding valuable insight on their perceptions and attitudes regarding the development of pupils' creativity, innovation and problem solving. Specifically, they considered such skills for adaptability as conferring a mix of individual and collective benefits, fostering practical competencies like originality, self-reliance and resilience to improve learners' everyday lives, and nurturing responsible citizens who can contribute to Rwanda's future and national development. All of the interviewees described the equivalence of skills between girls and boys, men and women, and several also highlighted their importance regardless of any child's apparent disability. However, there was diversity of opinion concerning the relevance of context in shaping the development and use of such competencies. Some respondents emphasised their equal value to learners in both urban and rural settings, while others cited differences in access to technology or exposure to agriculture as highlighting the salience of pupils' location.

Linking teacher responses back to *cognitive flexibility* as an underlying basis for these skills and as "creatively 'thinking outside the box,' seeing anything from different perspectives, and quickly and flexibly adapting to changed circumstances" (Diamond, 2014, p. 206) also provides an interesting angle on Rwandan education. Specifically, the participants discussed the importance of pupils being creative, original and unique, and the value of transferable skills to enable them to adapt to diverse work or geographic contexts. However, there was no explicit mention of children learning to take different perspectives, although this could be implied within the discussions on the diverse types of learners, such as children with special educational needs. Similarly, pupils' ability to engage with multiple perspectives could comprise an aspect of responsible citizenship, given references to empathy and tolerance in the competence-based curriculum (REB & MINEDUC, 2015).

Indeed, the teachers' responses often matched the language and content of the new curriculum. This could indicate that they truly embraced the competence-based approach to learning or that they were sufficiently well-versed with the relevant terminology to provide the 'correct' and desirable answers. The next chapter therefore builds on these findings and delves deeper, to examine *how* teachers and schools foster their children's cognitive competencies, both inside the classroom and beyond.

CHAPTER 7 – ENABLING COGNITIVE COMPETENCIES IN RWANDAN SCHOOLS (RQ4)

As outlined in Chapter 6, the qualitative component of the study and specifically the semi-structured interviews yielded valuable insights on Rwandan teachers' perceptions and attitudes concerning the development of their pupils' cognitive competencies. In addition, the interviews also provided an opportunity for inquiry into teachers' practices inside the classroom and wider processes within schools through which learners develop creativity, innovation and problem solving, as important 21st century skills closely related to their cognitive flexibility. However, as described above and in section 3.6.1, interviews have certain limitations, not least the challenge of distinguishing aspirational responses from actual behaviours in the real world. To mitigate this difficulty, I therefore observed a selection of lessons in the case study schools to triangulate the qualitative data, increase their accuracy and thereby answer the fourth research question (RQ4) which asks "What practices or behaviours are Rwandan public primary schools using to enable the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?"

In answering RQ4, this chapter builds on the contribution of the quantitative chapters to examine not just the measurement and development of children's cognitive flexibility in lower-income contexts, but also the educational practices or processes that could further its improvement. Of course, without longitudinal or panel data the study cannot assert any causality, but the qualitative research nevertheless offers value through an increased understanding of Rwandan teachers' opinions and perspectives, and by identifying existing behaviours within schools and classrooms that could potentially enable their pupils' cognitive flexibility development.

To explore these practices, the first section describes the analytical approach adopted to address RQ4, while the second section outlines classroom-based activities that may support learners' creativity, innovation, problem solving, and more general cognitive flexibility. The third section examines various relevant processes reported by teachers at the broader school level, which includes mechanisms for professional training and teacher collaboration, being the specific focus of the fourth section. The fifth section then considers current barriers and desirable changes, before the sixth section concludes the chapter with reflections on the findings.

7.1 Analytical Approach

Analysis to answer RQ4 drew on data from both the teacher interviews and the classroom observations. Prior to the interviews, I watched each subject teacher conduct two or three complete lessons over single or double periods, as dictated by the relevant school timetable. These observations helped me to contextualise their responses during the interviews, as well as raising issues or behaviours for follow-up discussion.

As noted in section 3.6.2, the observations and resultant narratives primarily focused on the teachers themselves, their practices, activities and demeanours, not least given the large size of the classes and the physical constraints of being a single observer. However, wherever possible, I also recorded details of particularly prominent pupils, for example, those that participated most actively in the lessons, those that received a higher proportion of teacher attention and those that overtly misbehaved or otherwise signalled their disinterest in the classes. During the interviews, I asked the teachers for such learners' names in the hope of drawing closer links between observed behaviours and children's performance in the quantitative assessments, but given the small size of the pupil samples compared to the overall Primary 1 and 4 cohorts, there was too little overlap to enable meaningful additional analysis. Notwithstanding this gap, the observations provided an important opportunity to witness the teachers in action, triangulate their behaviours in lessons and corroborate their interview responses.

7.1.1 Thematic Coding and Analysis

Coding for RQ4 used the same framework and six-stage approach for inductive thematic analysis outlined by Braun and Clarke (2006) and described fully in Chapter 6. Given the use of the two collection methods, however, the dataset was expanded to comprise both the interview transcripts and the semi-structured observation summaries. As for RQ3, and in the absence of any pre-existing or established coding schemes, I immersed myself in the data to generate preliminary codes for the teachers' responses and behaviours, which were then grouped under common themes and sub-themes, and subsequently refined according to their internal coherence and external distinctions. Appendix 14 sets out the final codes and themes used for the qualitative analysis.

Although the flexibility of thematic analysis confers several benefits as outlined in section 6.1.3, the openness of such an exploratory approach also posed certain challenges in coding the data. First, I needed to identify robust codes and themes that accurately reflected the teachers' accounts of their classroom practices, the specific activities that I observed during lessons, and my own interpretation of behaviours that could support the development of pupils' cognitive competencies. The latter was of particular importance where I witnessed pedagogical trends or common customs that teachers omitted to mention during interviews but which could directly affect children's cognitive flexibility, such as teachers' regular switching between English and Kinyarwanda.

Second, there were specific behaviours that could be assigned to more than one final code. Clapping, for example, appears to serve multiple purposes in Rwandan classrooms. Teachers use claps to command their pupils' attention, as part of energisers often combined with songs or rhymes, and as mechanisms to reward children for their participation or giving correct answers. A couple of teachers also used conditional applause, inviting their learners to clap only if they agreed with another pupil's response, to both incentivise performance and also assess wider comprehension within the class.

By contrast, two respondents described their learners taking part in contests and competitions. In one interview, the head teacher reported his pupils building their cognitive competencies by participating in external contests for creativity and spelling, while another respondent indicated the use of inter-class competitions as a means of assessing children's learning. In neither case, however, were the accounts corroborated by other teachers in their schools and so the initial sub-themes were ultimately combined with other broader codes on external engagement and assessment.

Finally, although NVivo offers appropriate functionality, the lesson observations were coded using the summary narratives only, and not the video recordings. Rather, the video footage was used to aid stimulated recall in the teacher interviews and to revisit key events and incidents during analysis to ensure the accuracy of my description. More detailed analysis of the recordings was beyond the scope of the present study, not least given their limited focus on the teachers' behaviours and the implications of translating lesson content in Kinyarwanda, both concerning cost and confidentiality.

7.1.2 Validity and Reliability

Notwithstanding these constraints, ensuring the validity and reliability of the data represented an important consideration throughout analysing the interview transcripts and observation narratives. Section 6.1.4 above describes the main issues affecting qualitative data, the need to establish authenticity, trustworthiness and credibility, and how these have been addressed throughout the study design and implementation. Indeed, the use of observations in addition to teacher interviews served to triangulate teachers' accounts of how they potentially foster pupils' cognitive competencies during their lessons. Regarding processes and systems *outside* the classroom and in schools more generally, I examined responses among interviewees working in the same school to corroborate their various descriptions.

In the case of observations specifically, reactivity, the extent to which research participants change their behaviours *because* of the observation, presented the most significant challenge to data validity (Robson, 2011). As outlined in section 3.6.2, I sought to minimise reactivity and distractions for both teachers and pupils by being as invisible and unobtrusive as possible, and by explicitly requesting that the teachers conducted their lessons as normal. Notwithstanding these efforts, the presence of a stranger and a white foreigner inevitably created some disturbance in the classrooms with some children regularly looking back at the recording equipment or at me. Typically, however, the learners became more accustomed to the observation as the lessons progressed to the point where, in one class, two boys even started to fight immediately in front of the camera.

Similarly, most of the teachers seemed largely unfazed by my presence in the classroom. A few of them glanced over repeatedly, which I aimed to discourage by minimising eye contact. Many teachers' common use of Kinyarwanda also suggested that they were not compromising authenticity or pupil comprehension for the sake of conducting a 'model' lesson. Only the classes by one teacher felt unnaturally scripted, staged or performed. He rewarded the learners, used group work and looked in my direction more frequently than the others, as though addressing me rather than his pupils, or seeking my validation or approval. However, none of his other behaviours or pedagogical practices were otherwise unexpected or unusual and so the observation narratives for his classes were nevertheless included in the RQ4 dataset.

Finally, I undertook the same checks and reliability analyses for the RQ4 coding as those described in section 6.1.4 above. First, I randomly selected, revisited and recoded 25 per cent of the interview transcripts and observation narratives, 2-3 weeks after the initial coding, which achieved an internal agreement of 99.76 and a Cohen's kappa of .93. Similarly, an independent researcher coded 25 per cent of the dataset documents, again randomly selected, which yielded 99.51 per cent agreement and a kappa of .87. In both cases, the coefficients and levels of agreement indicate a high level of reliability in the data coding (Miles & Huberman, 1994; O'Connor & Joffe, 2020).

With the analytical approach now set out, the following section explores the class-based activities and behaviours reported by teachers and observed in lessons that may support learners' cognitive flexibility and competencies such as creativity, innovation and problem solving.

7.2 Class-based Activities

Across the four schools, the scene in individual classrooms was fairly common with single teachers instructing lessons for between 40 and 65 pupils. In all schools, there were more learners in the Primary 1 than the Primary 4 classes, a mean of 54 children compared with 47. However, class sizes also varied by school and School 3 in particular accommodated more pupils per lesson, an average of 59 per class, than the other three schools where the combined mean was 48 children per lesson[48].

In each of the classrooms, the learners wore uniforms and sat in rows or around tables. The majority of Primary 4 pupils were seated at tables of between four and ten children, while most of the Primary 1 learners were in arranged in rows at desks of two or three pupils[49]. In some cases, the rows were oriented towards the blackboard at the front of the classroom, in others they faced into the centre so that the teacher could walk down an aisle between them. In most of the classrooms, there were some basic teaching or learning materials hung on the walls, often charts or diagrams, with children's work displayed in only a very small number of classrooms.

[48] These averages were adjusted for the differences between Primary 1 and 4 classes, and the number of observations at each level.
[49] In contrast to the other schools, all the pupils in School 3 sat at desks arranged in rows, in both the Primary 1 and 4 classrooms.

Within these contexts, the methods teachers used to develop their pupils' cognitive skills varied depending on several broad factors. Specifically, nearly half of the interview respondents, seven out of the 16 participants, reported that teachers' implementation of the competence-based curriculum and strategies to foster learners' creativity, innovation and problem solving are affected by the age and grade of the children, and the specific subject or content being taught. As one interviewee explained:

> So basically, yes, there are ways that [teachers] foster pupils learning these competencies in classrooms. It's mostly, it depends on the levels, on the level of the student, the class where they are, but…also the lesson they are taking. For example, it's more applicable in sciences (Female head teacher).

Another respondent concurred about the teaching of science and technology, suggesting that they provide space for learners to be creative and innovative. Similarly, several participants described the use of mathematical formulae to calculate shapes and spaces, and thereby aid problem solving when, for example, building a house or making furniture. By contrast, a couple of interviewees noted the difficulty of fostering creativity, or being expected to foster creativity, when pupils are in the very early stages of their education, learning letters of the alphabet, basic English or foundational numeracy.

Notwithstanding these differences, there were numerous common trends and themes across the various interview responses. First, the vast majority of participants, with only two exceptions, referred to group working as a key means through which Rwandan teachers enable their learners' cognitive competencies.

7.2.1 Working in Groups

Across the schools, all of the class teachers described placing children in groups and teams to work when asked how they or their colleagues fostered their pupils' creativity (*guhanga udushya*), innovation (*ubudasa*) and problem solving (*kwishakira ibisubizo*). Two of the respondents also mentioned the competence-based curriculum and their training on its implementation as guiding their use of this practice. These accounts thereby suggest a significant shift away from previous reports of Rwandan education as being "teacher-centred, with extensive lecture and little discussion" (Freedman et al., 2008, p. 680).

To a large extent, these responses were confirmed when conducting the various lesson observations. Although all of the teachers still used a considerable amount of whole-class teaching to present content, discuss ideas and invite participation, and some more so than others, the majority of them included at least one or two opportunities for learners to work together in small groups. In each case, the children would talk quietly on their tables, while the pupils seated in rows would often turn to collaborate with the learners behind or in front of them.

The teachers used group work for a range of exercises and activities. Examples from the observations included asking children to work collectively to perform mathematical calculations, order fractions and find square roots, or to discuss public assets, hygiene and the key components of the Rwandan flag. Several teachers also opened their lessons by asking pupils to discuss the 'class rules'[50] in groups before moving onto the more substantive content.

Between classes, the most noticeable difference concerned variation by grade. Specifically, while group working was a regular feature of all Primary 4 lessons observed, it was used rarely by the Primary 1 teachers. In such classes, there was a heavier reliance on plenary learning, although a couple of teachers used games in groups or teams to engage their pupils during lessons on letters, numbers and colours. Arguably, these games differed from group working in that the activity was undertaken by the whole class and without allowing any opportunity for the children to work together independently.

A common characteristic of group working in the Primary 4 lessons was the appointment of pupil leaders to represent each group. These learners were expected to help keep the other pupils under control and on task, and would often be requested to present the group's work or discussion to the wider class after working on the particular exercise. The appointment of group leaders varied between lessons and teachers: in many cases, they were elected by the group but a couple of teachers also described selecting leaders themselves, either to ensure that all children had a chance to participate or where the incumbent leader was failing to deliver on his or her responsibilities. However, certain pupils were evidently more likely to be chosen as representatives than others:

[50] These typically included instructions about not shouting, not fighting and listening to the teacher.

> So it's true, mostly the children who are faster learners, they are the most elected leaders even though they switch groups. But others want that fast learner to be the group leader because they know that through him [or her], they will perform better (Female Primary 4 teacher).

Teachers indicated several ways through which group working could foster children's cognitive competencies. First, and of most relevance to cognitive flexibility, pupils working in groups are more likely to be exposed to experiences, views and perspectives different to their own: "…that's beneficial in a way because…one child from the group might have a different experience from the others" (Female Primary 4 teacher). Similarly, and with specific reference to social studies, one teacher explained that *he* could also learn from any additional perspectives where pupils shared views or experiences that are not already captured in the textbooks: "…for example, when you take them in groups, sometimes you have different things in your book but…they bring others" (Male Primary 4 teacher).

Second, and related to this, various teachers reported that working in groups brings together diverse learners to nurture greater equality, tolerance and empathy. Two respondents explicitly mentioned the value of children working with the opposite gender: "…everything is done in groups now, everything, and you have to mix boys and girls, not saying 'Boys on this side, girls on this side', no, you have to mix them" (Female Primary 1 teacher). Likewise, another participant emphasised the importance of building harmony in a country previously affected by historical divisions and violent conflict: "…the students are now more centred on working in groups and in teams so this reinforces the unity among them" (Male head teacher).

Finally, many teachers emphasised the role of group working to support children's collaboration and teamwork skills, building their creativity and critical thinking as they complete the particular activities or lesson exercises. Indeed, learning from one another was a common theme across many of the interview responses:

> You take a group of students, you give them a book and…you give them…a task and you ask them to work together in collaboration as a group. So the one who knows more, the fast learner, can help the one who doesn't know much, the slow learner (Female Primary 1 teacher).

For numerous teachers, this pupil collaboration eased pressure on them and seemed to make their jobs easier. Especially in large classes, children were encouraged to ask their peers first, and the teacher as a second resort: “And when those pupils learn…they…start wondering ‘OK this, so we are working in groups…there’s something that I don’t know…I’ll ask my neighbour’” (Female Primary 4 teacher). Further, several teachers reported that by creating an additional space and platform to check their understanding, working in groups benefits weaker learners and timid children who are reluctant to speak up or ask questions in class, and thereby ensures that no one gets left behind.

Despite the apparent benefits of group working, however, a few respondents noted a couple of challenges in its use. First, they indicated that supporting children to learn in groups effectively is particularly difficult in large classes and with limited lesson time. One teacher explained that it can take 10 minutes to form groups, another 20 minutes to distribute the exercise and, in a class of 40 minutes, there is often very little time available for pupil presentations, discussion and feedback. Similarly, group work can limit teachers’ ability to follow the learning or development of any individual learner: “It’s very hard to track a child who is a slow learner because how can you tell if a child really acquired the knowledge…Maybe they copied just from the group members” (Female Primary 1 teacher).

In summary, working in groups featured prominently in the interview responses and the observed classroom practices, especially at the Primary 4 level. Such pedagogy appears to offer various benefits that can cultivate children’s cognitive competencies, not least by requiring them to engage with different perspectives and opinions, but possibly at the expense of charting individual pupils’ progress, at least within larger classes.

7.2.2 Practical Activities and Application

Like group work, another recurrent theme throughout the interview responses concerned the practical nature of learners’ skills as described and promoted by the competence-based curriculum. Indeed, section 6.3.1 above outlined the main practical benefits that Rwandan teachers associated with creativity, innovation and problem solving, not least their role in building originality, self-reliance and productivity. Activities observed in the classroom and reported by participants further attested to schools’ efforts to make education relevant to everyday life. Generally, these involved using practical exercises and examples, both inside and outside the classroom, and discussing with pupils at the end of each lesson the potential application of the content they just covered.

Specific activities and their practical implications varied most noticeably between the subjects being taught. As indicated above, numerous respondents described the use of mathematics and geometry for pupils to learn how to measure spaces and distances. Similarly, teachers in some of the classes observed used the division of familiar objects like sugarcane stalks to explain the significance of fractions, and one lesson even involved children physically cutting oranges into different-sized pieces. In social studies, learners examined various aspects of hygiene, income generation and financial saving, and discussed the differences between needs and wants, and public and private assets. Several participants also mentioned the value of pupils learning about healthy foods and one described a recent example:

> …children were learning about nutrition, learning about…a full course meal so they had…brought some food items from home and they went outside and they were talking about this and they were learning. So this helps our students when they go home, for example, they can advise parents if they eat let's say for example…*ugali*, let's say with beans and some vegetables, the child might say 'You know, Mum, we need a banana to make this meal, you know, rich and nutritious because the fruit will help us fight, our body fight diseases' (Female head teacher).

Within the classroom, various teachers indicated conferring certain responsibilities on learners to build their practical competencies. One interviewee employed a 'hygiene committee' to ensure that pupils were properly dressed in uniform, while another reported children's duties to keep their classrooms clean and tidy[51]. Such responsibilities also extended to learning *outside* the physical classroom. Several participants in two of the schools referred to involving learners in efforts to look after the school compound, gardening and agriculture. As one teacher explained:

> …we teach children how to farm…how to grow vegetables… We show them, we plant some vegetables and we tell them why they need to do that, we tell

[51] Pupils were observed cleaning their classrooms at the end of the day during several school visits.

> them that it can be a source of money. And we also try to motivate them, tell them for example, we teach them how to raise chicken…this can be a great source of income…and show them by practice. We teach them how they can be resourceful (Male Primary 4 teacher).

Finally, five out of the 16 respondents described discussing with pupils the practical application of their learning at the end of their classes. These discussions were observed in numerous lessons, at both Primary 1 and 4 levels and particularly in School 4. They were often framed in relation to 'cross-cutting' issues and values defined by the competence-based curriculum, including topics like gender, peace and sustainability education (MINEDUC, 2015a). Examples used in the classes observed involved explaining the importance of fractions to share food, starting businesses to generate income, maintaining hygiene to avoid infection and learning basic arithmetic to ensure financial literacy: "So I was telling them if their parents send them to buy something at the shop, they have to know how much they will pay and the change they come back with" (Female Primary 1 teacher).

In summary, the teachers interviewed and observed described various mechanisms for making pupils' education applicable to their everyday life. Related to this, many respondents also employed a range of learning aids to make their lessons practical and relevant.

7.2.3 Use of Learning Aids, Materials and Techniques

Throughout the interviews, participants indicated using numerous different learning aids, materials and pedagogical techniques, over and above group working and practical exercises, to foster their learners' cognitive competencies. These accounts were largely corroborated in the lesson observations. Teachers presented their class content and activities with the support of traditional learning tools like wallcharts, flashcards and textbooks, as well as more habitual items that children might have seen in their homes. Regarding the latter, particular objects included pieces of fruit, cups, Rwandan peace baskets filled with sorghum, items of clothing, and bottle tops and stones for counting. By using familiar objects, the teachers sought to make their lessons more relatable to daily life:

> For example, when I was teaching about clothes, I brought my kids' clothes to the school. This helps the students to understand that we are not just studying

> imaginary things or drawings because they are able to see them live, and connect it to what they already know (Female Primary 1 teacher).

As part of this initiative, several teachers also reported asking their pupils to bring certain learning aids to their classes. Although the practice was not expressly witnessed during observations, the interviewees nevertheless described it as encouraging children's creativity by involving them in the process, and by enabling them to draw connections between their school lessons and home life.

More traditional learning aids similarly featured throughout the observed classes and interview responses. Two of the Primary 4 mathematics teachers used flashcards in their lesson exercises, typically displaying an equation for the pupils to solve individually or in groups. Likewise, numerous teachers across the subjects presented wallcharts showing, for example, different body parts, pieces of clothing and the Rwandan coat of arms.

A few respondents described their use of textbooks in lessons to aid children's learning and cognitive skills. They often referred to the linkages between teacher guides, the course materials for students and the competence-based curriculum. One participant reported a specific activity as follows:

> For example, during the social studies class, what I do is take a book and a title. I give it to them and tell them to go read and then they will come afterwards telling, speaking about what they read from the book (Female Primary 4 teacher).

However, in reality, relatively few textbooks were seen to be used during the lesson observations. The teachers would indeed refer to the books themselves, consult them to copy content onto the blackboard, and even show the relevant open pages around the class, but in only one of the 26 lessons observed did the pupils touch or use a textbook themselves[52]. Reasons for this difference between interview responses and observed behaviours could include teachers reporting aspirational and desirable practices rather than everyday occurrences, or that textbook use was reserved for older learners in Primary 5 or 6. Section 7.5.2 below also potentially sheds some light on this discrepancy.

[52] The specific class was a mathematics lesson, with the textbooks shared one between three pupils.

The situation regarding classroom use of ICT was somewhat similar. Four of the teachers described their school using computers to engage pupils, enhance creativity and deliver the competence-based curriculum, but none of the lessons observed involved any use of technology. In this case, the reason could be that computers were only used in designated ICT classes, and not lessons on social studies or mathematics. In three of the schools though I did see large numbers of laptops in the staff or computer room, in some cases being prepared for what appeared to be imminent use by students.

With particular reference to creativity and innovation, over half of the interviewees described involving children in some kind of craft-based activities. Primary 1 teachers mentioned drawing, while a mix of respondents reported pupils using cardboard or other materials to make toys or models such as clocks and houses. Beyond more expressive and artistic endeavours, several participants recalled learners producing practical objects for use at school, for example, board dusters, waterproof chalk boxes and playground markers. Many interviewees also described pupils making items in clay, recognising the potential value of their innovation:

> …we have been teaching children how to make charcoal stoves from clay, or pots or cups or cars. For example, they can grow up and they can make business out of this creativity they have, they can design them and then they can sell those things and hence make money without waiting for external support (Male Primary 4 teacher).

As with teachers' use of ICT, I did not witness any actual examples of learners participating in craft lessons, however, clay pots and other objects on classroom shelves corroborated at least some of the respondents' accounts.

In addition to the physical and tangible learning aids that teachers used in their classes, I observed a couple of pedagogical practices common to most, if not all, of the Rwandan lessons. The first concerned teachers' means of incentivising and rewarding pupils, and the second their use of songs, games and energisers to maintain children's interest and attention.

Regarding the former, all of the teachers in both Primary 1 and 4 classes had mechanisms to promote participation, motivation and confidence among their learners, and to encourage them to give correct answers. Typically, these involved clapping for pupils or giving them 'flowers' or 'rain'. As one interviewee explained:

> It's a way of rewarding children. If they do something well, you give them an exercise and they perform it well, if you give them a 'flower' you can find they are very happy and the other kid can say 'I also want to get flowers'. It's a way of motivating them (Female Primary 1 teacher).

Three of the teachers also used a point or star-based system to manage their classrooms. For example, they drew pictures of happy and sad faces on the blackboard and told children that they would gain points or stars for good conduct, and lose them for any misbehaviour. A couple of the teachers further advised pupils that they would be allowed to sing a song at the end of the lesson if they had achieved a certain number of points.

Songs, rhymes and games played another important role in the classroom to keep learners energised and engaged, but also to build their skills and enjoyment. In particular, one teacher indicated that singing could help nurture the children's creativity:

> …for example in music, I teach, I can come up with a song and teach the pupils the song and I encourage them again to sing it with me and also I encourage them to even create their own songs…I do this in order to try to fuel their music talents (Female Primary 1 teacher).

Several teachers also used games to make the lessons more interesting and fun, especially for the younger learners. In one class, the Primary 1 teacher allocated each pupil to one of three teams, and each team a colour. When she called out a particular colour, the children in that team were to stand up, but not otherwise. Games could also involve activities outside the classroom, including sports or running competitions in the playground: "They are very young and you can't let them hang in the classrooms all the time. They will get easily bored and they won't like it. So we have to take them outside" (Female Primary 1 teacher).

Indeed, many of the interviewees noted the value of physical movement to keep learners alert. Teachers in both Primary 1 and 4 classes used a mix of techniques to break the routine if they sensed the children becoming weary. These included clapping with rhymes or chants, jumping, dancing and inviting the pupils to stand up and sit down again repeatedly: "when you tell them to stand up and clap…it's physical exercise then they will easily not be bored" (Female Primary 1 teacher).

In addition to bodily energisers, the Primary 1 teachers in particular used several 'call and response' mechanisms to ensure learners' attention. These involved the teacher shouting a word and the children responding together in unison, bringing their focus back to the lesson. As one respondent explained:

> It's a convention, it's an agreement that I had with them that if I say 'We!' they say 'Wa!' but they also get sharp and they get their attention back to me… One pupil is looking on the side, then the other is distracted and when I say 'We!' they all get back to me (Female Primary 1 teacher).

In summary, the teachers interviewed and observed used a range of traditional and more improvised classroom props to support their children's learning. They also employed similar strategies for incentivising pupils with claps and 'flowers', and for maintaining their focus and engagement. These latter techniques to briefly disrupt the main lesson and thereby keep learners energised nevertheless highlight another common feature across the lessons, that relating to transitions in the classroom.

7.2.4 Classroom Transitions

Moving between different activities is a natural part of classroom lessons. Often teachers switch between plenary discussions and explanations to individual exercises or, as described in section 7.2.1, group-based working. As indicated above, such changes can also be important to ensure that learners remain concentrated, attentive and interested.

Given the focus of this study on cognitive flexibility, which includes "quickly and flexibly adapting to changed circumstances" (Diamond, 2014, p. 206), such transitions warrant particular attention. Although none of the teachers expressly raised these switches in interviews, not least because they were asked about the development of pupils' creativity, innovation and problem solving, several different types of transitions appeared throughout the lesson observations. These could be generally categorised as transitions between activities, transitions between languages and transitions between rules.

To better understand these transitions, I created codes in NVivo to analyse their frequency within the classes observed. Regarding the former, I recorded each time the teacher switched to a different kind of classroom activity. Specifically, these captured every instance of a teacher moving from plenary whole-class instruction, to individual work, group-based exercises or pupil energisers, and *between* these various types of activities. Of course, whole-class teaching can involve multiple different endeavours, teachers lecturing on new content, facilitating class-wide discussions or conducting collective exercises to check learners' comprehension, but from the point of view of individual children, all such activities entail them focusing on the teacher and the class at large. Similarly, transitions can involve changes at various levels, between examples or different pupils, but I concentrated on switches between broader activities in the interests of achieving some degree of parsimony.

Regarding language, and as explained in Chapters 2 and 3, English became the official medium of instruction in Rwanda for learners in Primary 4 and above in 2008, and more recently for *all* primary pupils from 2020 onwards (Edwards, 2019; Williams, 2020). Nevertheless, teachers across the classes observed often reverted to Kinyarwanda to ensure their learners' understanding of the lesson: "…sometimes children, because they come they have no background in English, I have to explain in Kinyarwanda telling them" (Female Primary 4 teacher). In which case, I also coded every occasion where they transitioned from one language to another.

Table 7.1 below summarises the frequency of teachers' switching between activities and languages in the different grades and subjects. Overall, it shows that such behaviours were fairly common practice across the lessons observed. The higher usage of Kinyarwanda in Primary 1 classes is also unsurprising given that such pupils were fairly young and right at the start of their formal education. However, these data cannot be used to draw any inferences regarding causality in children's learning, nor to identify any actual relations with their cognitive flexibility development.

Table 7.1 - Frequency of Class Transitions between Activities and Languages

Class Type	Transitions between Activities		Transitions between Languages	
	Range	Mean	Range	Mean
Primary 1 English	4-18	10.75	13-22	15.50
Primary 4 Mathematics	5-20	13.75	1-26	8.50
Primary 4 Social Studies	6-23	11.75	6-23	11.75

Source: Primary data, 2018.

By contrast, transitions between rules were much less frequent. In this case, I coded instances where pupils were expected to change their responses within a particular exercise, being reminiscent of the measures for cognitive flexibility described in section 3.6.3, the results of which are set out in Chapters 4 and 5. Indeed, there were only several examples of transitions between rules across the lessons observed, but on each occasion they highlighted the learners' difficulty in adapting to the changing circumstances.

First, in a class on numbers, the Primary 1 teacher invited the children to stand up and count on their fingers together from one to five. She repeated the exercise several times then told them "Now we're going to count three only", but most of the pupils continued to count to five. The teacher repeated the instructions again and they correctly counted to three. However, a few moments later, following directions to count from one to four, a small number of children still counted to five. Similar incidents took place with Primary 1 learners in two other schools. In these cases, the English lessons focused on verbs and identity and involved the children stating whether they were boys or girls. On both occasions, young boys either individually or collectively repeated the preceding answers to state "I am a girl", much to their peers' amusement.

Finally, in a Primary 4 mathematics class, the teacher asked learners to arrange fractions with the same denominator into ascending order. After several successful exercises together and in groups, she then asked them to put the fractions into *descending* order, explaining that it meant starting with the largest and going down. Numerous pupils tried to answer but despite the teacher repeating the instruction and advising them "You can start by the biggest", one learner only achieved the first correct response on the sixth attempt.

In each of these examples, the teachers' use of English might have explained some of the pupils' difficulties. When asked during her interview, however, the mathematics teacher thought that the notions of ascending and descending order had been taught too close together: "I think the confusion originated from the fact that I taught the same, those two concepts, in the same day. It would have been much easier if I taught on one day descending, on the other day ascending" (Female Primary 4 teacher).

To summarise, these instances of transitions between activities, languages and rules in Rwandan lessons highlight regular switches in the classroom which may deliberately or inadvertently nurture children's cognitive flexibility. Nevertheless, knowing if and how learners are developing such adaptability depends, to a certain extent, on how such skills are being assessed.

7.2.5 Assessment Practices

The preceding sections identified different techniques through which Rwandan teachers, both intentionally and incidentally, might be fostering their pupils' creativity, innovation, problem solving, and underlying cognitive flexibility. To ascertain whether this was the case, the interpreter and I therefore asked the teachers during interviews about how they assess these competencies in their classrooms.

Overall, the responses were fairly broad and many participants described processes and principles of assessment generally rather than efforts to measure these skills for adaptability specifically. Nevertheless, the respondents outlined practices that could be categorised according to two themes: formal tests and examinations, and more naturalistic approaches like case studies and exercises.

Regarding the former, the majority of interviewees referred to written tests, quizzes and assessments conducted within their school on a regular basis. These may take place at the end of each week, month and term, and indeed the period available for the quantitative fieldwork was cut short to accommodate end-of-term assessments. The teachers described the goal of such tests to determine whether pupils had understood the content, to track their progress and, in the following response, to report to parents:

> Every month we have an assessment. We assess children and see the level of understanding of the material. Not only that but also after every course, after every class, I have to do a general assessment of applicability, if they can apply what they have learnt. So basically you assess the performance or the understanding of a child by giving them assessments… And then we show the results to their parents to keep them updated about their kids' performance (Female Primary 4 teacher).

Related to these assessments, several participants mentioned the role of *external* examinations. They outlined practices for developing and distributing papers at the district or regional levels, through the REB, and as part of the primary leaving assessment system. One of the interviewees also indicated that such examinations could provide valuable insight on the success of the competence-based curriculum and its effective implementation in Rwanda.

In addition to formal assessments, half of the respondents described more informal approaches to gauging pupils' progress and the attainment of key cognitive competencies. Some teachers reported the use of 'case studies', presenting learners with hypothetical scenarios or problems and asking them to explain how they would respond. Others indicated that they determined children's learning through practical exercises, homework and inter-class competitions. Interviewees in several schools even mentioned use of Bloom's Taxonomy, which was posted on some of the staff room walls, as shown in Figure 7.1. One teacher explained that it helped to ensure that pupils advance from basic to more advanced levels of performance and application:

> …there is a strategy called Bloom's Taxonomy…it's a framework of assessing competencies, of assessing…pupils' learning… And you can do it to, at any level so you start by simpler questions and then you end up with tough questions and at every level where the pupil is…you have a way of assessing their learning to both slow and fast learners. But this needs that teachers be trained how to use this strategy (Male Primary 4 teacher).

Indeed, a few participants reported that the assessment of children's broader skills under the new competence-based curriculum is still evolving. They described that there is ongoing uncertainty about the measurement of such capabilities generally, the materials and resources needed, and the most effective way to train teachers accordingly: "I think that we don't have yet a fixed way and framework of doing that… So I would say that the assessment is not in a good shape, as the teachers themselves are still learning the system" (Male head teacher).

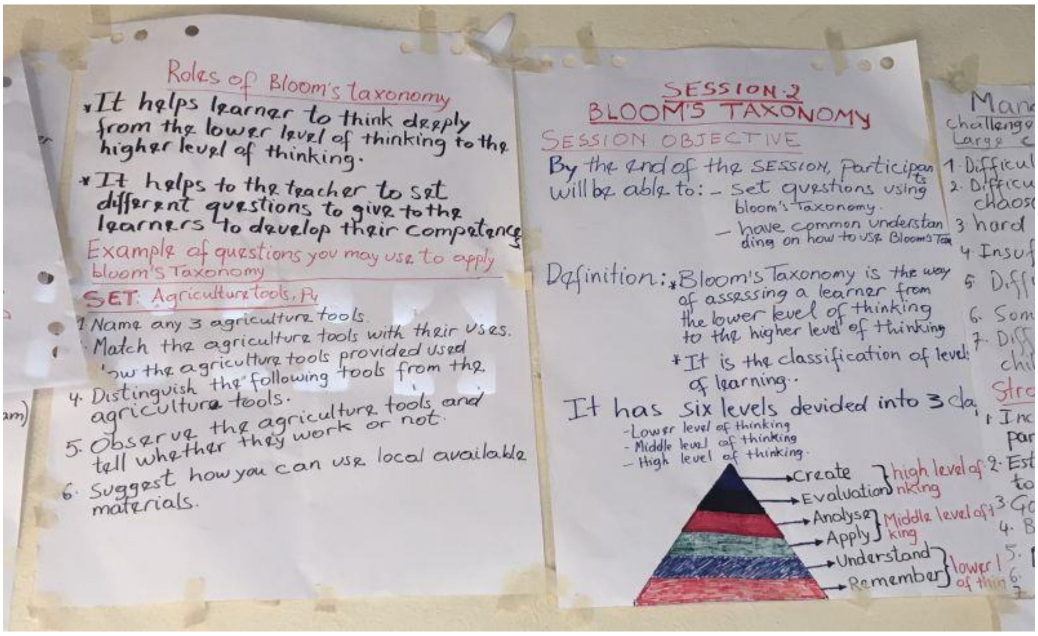

Figure 7.1 - Posters of Bloom's Taxonomy

In summary, the respondents indicated a range of approaches to measure pupils' competencies and I frequently observed teachers conducting class exercises or setting homework for children to test and consolidate their learning. A couple of interviewees further recounted that assessment had comprised part of recent trainings, suggesting that it may be a priority for Rwandan education in the near future.

7.3 School-based Activities

Beyond class-based activities, the interview questions also explored wider school practices and systems that could nurture learners' cognitive competencies. For such processes, I compared the accounts of different teachers in the same schools to triangulate their responses and to establish the actual situation. A detailed investigation of these systems, however, is beyond the scope of the current study.

Participants described practices that cut across different pupil grades and could be grouped into three broad areas: clubs, whole-school activities, and engagement with external bodies.

7.3.1 Clubs

Multiple teachers at each of the schools identified extra-curricular clubs as creating important opportunities for children to develop cognitive competencies like creativity, innovation and problem solving. Such clubs reportedly cover a wide range of issues, not least culture, human rights and first aid, with the most frequently mentioned clubs relating to drug abuse, AIDS and environmental protection.

Respondents described clubs as playing a huge contribution to students' growth, complementing their learning from more formal lessons. They indicated that in certain clubs, pupils are able to expand practical skills such as speaking, while in others they have space to play games, learn shared values and engage in creative activities like making crafts or writing songs or poetry. Some clubs have been established to tackle pressing concerns or social challenges in Rwanda:

> There are many clubs, for example, environmental clubs. Children participate in those clubs and they learn the importance of the environment, how to take care of it and why we need to take care of it. There are also other clubs, for example child protection club where children learn that…violence between one another is not good, a child deserves to be protected, and the society in general needs peace so that's where pupils learn that (Male Primary 4 teacher).

The organisation of the clubs varied across schools. In each case, interviewees reported that they were led by one or more teachers who could also engage external expertise where specialised activities, such as shoe-making, were involved. Eligibility, however, was mixed and not all clubs in all schools seemed to admit children from the lower primary classes.

Some schools apparently encouraged all pupils to join at least one club, however, scheduling could occasionally limit participation. Respondents in two schools explained that 'clubs time' was built into the weekly timetable, which meant that enthusiastic learners might have to pick between the different clubs. In another school, the scheduling was much more ad hoc:

> What happens is the club teachers, the teachers in charge of the clubs…what they do is, you can request from the head teacher, from the administration, say

> ‘In this time, this given time I would like to be with the children. Please allow me to do so’ (Male Primary 4 teacher).

In addition to clubs, nearly half of the interviewees also discussed activities undertaken by their schools as a whole as further practices through which they fostered pupils’ cognitive competencies.

7.3.2 Whole-school Activities

The two types of whole-school activities that teachers perceived as relevant and valuable for children’s cognitive development were assemblies and Rwandan cultural and civic leadership training, known in Kinyarwanda as *itorero*.

Several teachers first described daily assemblies as providing an important opportunity for their school to build their learners’ thinking skills: “…when they’re outside on the assembly, for example we speak to them, we tell them about different topics which…help us foster some thinking, way of thinking into them” (Female Primary 1 teacher). They explained that the school came together each morning for 5 to 15 minutes before lessons during which time the teachers can raise and discuss issues, like sustainability and national development, and even conduct a pupil vote.

Assemblies can also be used to instruct learners on Rwandan cultural values and five of the 16 interviewees indicated the importance of *itorero* for ensuring children’s correct and holistic development: “That’s where we teach pupils these competencies and values, cultural values of a Rwandan” (Male Primary 4 teacher).

Itorero is a reportedly pre-colonial Rwandan tradition and a training system for civic education, patriotism and the socio-political development of the country (Rwanda Governance Board, 2017). The practice was reinstated between 2007 and 2009 as part of efforts to rebuild Rwanda and involves decentralised training for citizens, including students, from all walks of life (Purdekova, 2014; Thomson, 2018). *Itorero* aims to build unity within the country, so-called ‘Rwandanicity’, not least by teaching its national history and encouraging the fight against genocide ideology.

The interview responses echoed many of these objectives. Participants described the role of *itorero* to promote agency, self-reliance and a sense of citizenship and responsibility among their pupils. Within schools, however, the delivery of *itorero* seemed to vary, with some teachers suggesting that it takes place daily, either during assembly or at the end of the school day, while others indicated that it runs weekly, possibly even in parallel with different school clubs. If and how pupils' participation in *itorero*, indeed in assemblies and extracurricular clubs, is affected by double-shifting and children only attending school for 4 to 5 hours per day was unclear from the teachers' responses.

7.3.3 External Engagement

In addition to clubs, assemblies and *itorero,* several interviewees outlined their schools' engagement with external organisations when asked about how they fostered learners' cognitive competencies outside the classroom. Broadly, such engagement either involved external bodies or individuals coming *into* the schools, or staff and students themselves venturing *outside* school premises to visit different organisations.

Regarding the former, the respondents described attendance in schools by representatives from government to address pupils either in assembly or individual classes. These sessions reportedly covered general issues like the environment or more practical topics, for example, guidance on how to access e-government services. A couple of teachers also mentioned support from international NGOs, such as previous collaborations with Right to Play, although more interviewees referred to NGO engagement in the context of teacher training, as discussed in section 6.2 above.

Two respondents offered examples of their staff or children participating in activities outside their school. One teacher mentioned occasional visits to local businesses like clay factories or rope manufacturers for pupils to learn about production. Another interviewee recounted children from his school competing in inter-school contests on spelling, creativity and debating. He further described his pupils going to visit a local private school as part of a student peer learning exchange. However, a teacher at another school noted the practical constraints that limited such visits:

> I think there are not quite many activities, probably because of financial capabilities. I wish we could be taking outside trips or visit businesses and talk with business owners…so that they speak with children and children see in practical how businesses are run and how things are done. But I think we don't do that quite often because the school doesn't have financial capabilities (Male Primary 4 teacher).

To summarise, the interview participants outlined various school-based activities through clubs, assemblies, *itorero* and external engagements that they considered to help pupils develop cognitive competencies. Indeed, there were overlaps between the practices described, for example, clubs inviting outside speakers or specialists and aspects of *itorero* being covered in school assemblies. Together with the classroom practices described in section 7.2, the Rwandan teachers perceived these behaviours and activities as helping to nurture their learners' creativity, innovation and problem solving. However, the extent to which teachers themselves are competent to foster such skills depends on their own training and professional development, which comprises the focus of the next section.

7.4 Teacher Support and Development

Section 6.2 above detailed key characteristics of the head and class teachers that were interviewed and observed across the four Rwandan schools. These included their gender, years of experience and participation in trainings over the preceding 12 months, both within and outside their schools. In addition to this information, the interpreter and I also asked the respondents about any teacher collaboration, peer learning or other support between them and their colleagues *explicitly within their school*. Specifically, we were interested in schools' own systems and processes for professional cooperation or development that could help teachers to better build their pupils' cognitive competencies.

The interviewees described a range of different approaches. These could be broadly categorised as collaborative lesson planning, observations and more formal in-school training, although there was some degree of fluidity between the three.

First, respondents in each of the schools reported teachers taking part in collaborative lesson planning, often through 'continuous learning groups' or 'communities of practice'. Such planning was generally organised according to subject and department, but some teachers intimated collaborating with colleagues working with pupils in the same grade or even other primary classes. Interviewees saw this cooperation as an important way to exchange ideas, share best practices and find solutions to common problems:

> We are two teachers per every level who teach the same course, class, and we do help one another, we do support one another through lesson planning. No one does lesson planning by themselves, we do this together and we help one another. For example, if I don't understand something, a teacher will help me or I will help them if they don't understand something (Female Primary 1 teacher).

Across the schools, the vast majority of respondents also described participating in lesson observations although these could take several possible forms. First, nearly all of the teachers had been observed once or more by their head teacher or director of studies during the preceding year. Table 7.2 below builds on Table 6.1 to include details of class teachers' formal observations, in addition to their recent trainings. Entries in red indicate activities conducted internally within the school and show that most teachers had been formally observed at least a couple of times by their school management over the previous 12 months. Feedback to the teachers after the observations varied, but focused on group learning on at least a couple of occasions.

Table 7.2 - Overview of Teacher Respondents including Training in School

Class Grade	Subject(s)	Gender	Years as Teacher	Years at School	Training(s) Received in Past Year	Lesson Observations during the Past Year
Primary 1	English, Drawing and Music	Female	6-10	0-5	2 trainings on CBC over a total of 7 days in own school by SBM on lesson planning	1 by REB; feedback on child cleanliness
	English	Female	11-15	11-15	Ongoing CBC training by other teachers in own school every Tuesday and Friday; external training for 2 days on teaching religion	3 – 1 by director of studies, 1 by SEO, 1 by MINEDUC officer
	English and Social Studies	Female	6-10	0-5	2 trainings on CBC comprising 2 weeks and 1 day on using the new teaching methods by teachers in another school and Wellspring (organised by subject)	2 by head teacher; feedback on general learning process including classroom and child cleanliness
	English and Mathematics	Female	6-10	6-10	CBC training for 2 weeks by REB outside the school, 1 day on English and 1 day on mathematics by Building Learning Foundations and ongoing support from Wellspring based on needs assessment	9 – 6 by head teacher, 3 by Wellspring; feedback on lesson planning, cross-cutting issues, time and behaviour management
Primary 4	Mathematics and French	Female	15+	15+	CBC training weekly (Saturdays) by SBM in own school on teaching methodologies, including digital learning and Bloom's Taxonomy	6 – 4 by head teacher, 2 by others; feedback on using teaching materials and reinforcement of good practices
	Mathematics	Female	15+	15+	3 trainings on CBC comprising 1 week, 2 days and 1 day by teachers in another school on lesson planning, behaviour management, critical thinking and values	4 – 2 by head teacher, 2 by Wellspring; feedback on cross-cutting issues such as gender
	Mathematics, English and French	Male	6-10	0-5	Termly with Wellspring, monthly with the sector, weekly follow-up from Wellspring; CBC training on topics including assessment for 9 days in Rwamagana and ICT training for 1 week both by REB	4 – 3 by Wellspring, 1 by head teacher; feedback on group learning
	Mathematics, Social Studies, French and Sports	Female	11-15	11-15	3 trainings on CBC regarding preparing courses and cross-cutting issues such as gender, critical thinking and communications for a total of 4 weeks and 4 days by teachers from own school trained by REB; One Laptop Per Child training every morning for a month by teachers from own school trained by REB	3 – by director of studies; feedback on using group work and getting to know the pupils
	Social Studies, Religious Studies, Science and Technology	Male	6-10	0-5	2 trainings on CBC over 4 Saturdays in own school by SBM and IEE on lesson planning, cross-cutting issues, generic competencies, evaluating, using teaching and learning materials; 2 days external training by the REB; 5 days external training on English and using learning materials by Building Learning Foundations	3 – 2 by head teacher, 1 by SEO; feedback on improving learners' English
	Social Studies and Science	Female	6-10	0-5	1 training on CBC for 1 week by REB in Nyanza; 1 training on mentorship for 3 weeks by the University of Hertford in Rwamagana	3 – 2 by the director of studies; 1 by the former head teacher (no recollection of the feedback content)
	Social Studies, Science and ICT	Male	6-10	6-10	3 trainings on ICT lasting 2 weeks and 1 week and 3 trainings on CBC lasting 2 days each both by REB, 2 trainings on English lasting 1 week by Wellspring, all at external locations	10 – 6 by head teacher, 4 by Wellspring sector trainer; feedback on using learning aids, encouraging learners to speak and giving them more time
	Social Studies and English	Male	11-15	0-5	2 CBC trainings for 3 weeks and 1 week by REB in multiple locations on teaching knowledge and skills; online training for 1 year by KIE; training with Wellspring 6-9 times a year	15 – 6 by head teacher, 9 by Wellspring; feedback on class management, topics, learning aids, cross-cutting issues and values

Source: Primary data, 2018. Notes: Red text indicates trainings or observations at the respondent's own school. CBC = Competence-based Curriculum; IEE = Inspire, Educate and Empower Rwanda; KIE = Kigali Institute of Education; SBM = School-based Mentor; SEO = Sector Education Officer; VSO = Voluntary Services Overseas.

In addition, several interviewees described a more informal system of observing *one another's* lessons. They explained such process as being mutually beneficial, with the observer learning from the practices of his or her colleague, and then offering suggestions to the observed on how he or she could improve the class. Indeed, depending on their availability, multiple teachers could observe the same lesson at once:

> I'm a mathematics teacher and if I'm going to practise the peer learning with all my colleagues, all of them who teach mathematics will come and observe me doing my class and if another teacher who teaches sciences is going to do that, then all the science teachers will come and observe her. So that's how we support each other (Female Primary 4 teacher).

Finally, a few respondents referred to a process of observing so-called 'model lessons' or 'lesson studies'. These could involve a trainer or school-based mentor delivering a class to share particular content or demonstrate a certain technique, or the mentor or another teacher conducting a lesson to *other teachers* in the school:

> We do this through peer learning and lesson studies where a teacher goes in front and teaches other teachers… The other teachers observe how the teacher teaches and even the teacher who is not helping well the children in learning…so that they can improve (Female head teacher).

In addition to observations, the interviewees described more traditional forms of training taking place within their schools. Teachers in multiple schools reported receiving such support from their mentors, but only one school appeared to have a dedicated school-based mentor without his own teaching workload. Although he worked across two schools, his time within the case study school was focused purely on teacher training and implementing quality improvements. Respondents indicated attending his sessions but also consulting him for advice when facing a particular pedagogical challenge: "…the school mentor, when you don't understand or when you face a challenge, you go and speak to them…when they find something new or when they're from a training…they also come and share the knowledge with us" (Female Primary 1 teacher).

By contrast, the other schools had specialised teachers, often referred to as ‘multipliers’ or ‘subject leaders’ who had received additional training from the REB, Wellspring or other external bodies and who were designated to coach their peers: “…when we started working with Wellspring, they chose some teachers whom they work with from the school and those teachers their job is, their duty is to also coach other teachers” (Male Primary 4 teacher). However, these multipliers also had their own teaching responsibilities and so limited time for delivering formal training or one-to-one mentoring to the other teachers.

The content of these trainings varied, with interviewees recounting sessions on lesson planning, teaching methodologies, the inclusion of cross-cutting issues and how best to foster learners’ generic competencies. Indeed, many of the trainings comprised the mentor or multipliers cascading knowledge from trainings that they had attended, often relating to the implementation of the competence-based curriculum:

> For example, we share knowledge about the CBC. When we participate in trainings, some teachers go and they come back and they teach others so every teacher is updated and they know what’s happening, they know what they should be doing (Male Primary 4 teacher).

Overall, the schools appeared to be using a blend of approaches to promote their teachers’ professional development and thereby further their pupils’ cognitive competencies. Between schools, the main differences concerned the availability of support from a school-based mentor and, probably as a result, the frequency of the trainings. As noted above, only one school had a designated mentor without his own teaching workload and the respondents in that school consistently described a pattern of weekly trainings. By contrast, although teachers in other schools mentioned regular collaboration by way of lesson planning or reciprocal observation, formal trainings seemed to be more sporadic or externally driven, for example, following attendance at a REB or Wellspring training session, a study exchange with another school or even the emergence of a new and pressing academic need.

Related to this, the teachers reported a mix of feelings regarding their own confidence and preparedness to deliver the revised curriculum. To explore particular gaps and also better understand any barriers that might impede schools’ abilities to nurture their learners’ cognitive competencies, the interviews also comprised questions to teachers on how they would change or improve the existing system.

7.5 Desirable Changes

The participating teachers described a variety of desirable reforms or changes that they perceived would improve their instruction, and consequently their pupils' skills development. Such changes broadly concern either the organisation or the delivery of primary teaching, but several respondents were explicit that it was still too early to opine on the success or otherwise of the competence-based curriculum. Many interviewees also discussed the 2008 reform that introduced English as the official medium of instruction as a major challenge, both for their teaching and their children's learning, but without necessarily suggesting that it should be revised or reversed.

7.5.1 The Organisation of Teaching

First, regarding the organisation of teaching and learning, numerous participants described the timing and scheduling of classes as posing a major challenge. Some of them complained about the ongoing double-shifting, the limited contact time and pupils having to alternate between lessons in the morning one day and not again until the following afternoon: "…it's not good for the kids because…it's a few hours…tomorrow they come back, like, if they didn't learn anything the previous day...they leave everything at school in the classrooms" (Female Primary 4 teacher). A few teachers in particular contrasted the short school days for children with their own long working days, from 7am to 5pm, and noted the difficulty of monitoring the progress of specific children given the continuous interruptions to their learning.

More broadly, one respondent commented on the wider scheduling of the Rwandan school year. He suggested that the academic calendar was mismatched with the country's seasonal climate, which could affect pupils' disposition and mental capacity to learn:

> Even we are going to enter into [a] period of sun, from May to August, it is a period of sunshine... The learners in the classroom, they are sleeping, they come late, even it is about the changing of period of study (Male Primary 4 teacher).

For some participants, the limited teaching time was exacerbated by expectations placed on them by the competence-based curriculum. In particular, the teachers described the challenge of introducing a topic, facilitating practice exercises or group working *and* discussing cross-cutting issues, all within a 40-minute period:

> So the first thing would be to increase the learning time. As you have seen a course, a class is only 40 minutes and the number of children is big even though we put them in groups which eases the pressure a bit, but it's still not sufficient…they have so many children and following individual children is very difficult (Female head teacher).

Related to learning time, nearly half of the interviewees commented on the large size of classes and the need to work with fewer pupils. Respondents indicated teaching classes with up to 70 children in some schools and explained the difficulty of providing tailored feedback to individual pupils where there was so little contact time per learner. As one participant advised "the first thing is to reduce the number of students in a classroom, because if there are many, it's very hard to follow up on each of them" (Female Primary 1 teacher).

In a similar vein, one respondent proposed that learning should be organised by class, rather than by subject. She implied that this would offer greater continuity for children and increase teachers' ability to track their progress:

> …a comment I can make is about the new structure of rotating teachers where every teacher has a course they teach…I believe that it has a negative impact on the lower levels of classes from P1 to P3 because those pupils are still very young. They are, you know, they look when the teacher comes in, they only focus on what the teacher is wearing…so if after 40 minutes they really haven't caught anything…I think the classroom should have one teacher from P1 to P3 (Female head teacher).

This recommendation was of particular interest, both because it suggested a stronger emphasis on children's cognitive development and because it echoed the response of an interviewee during the 2012 study (Bayley, 2015).

Finally, a number of participants reflected on the efficacy and inclusiveness of current processes for enacting Rwandan educational reform. First, several respondents described an apparent paradox regarding the pace of reform in the country. On the one hand, they reported MINEDUC delays to enact necessary changes, not least to increase learning time and reduce double-shifting. On the other hand, they highlighted the importance of time for ambitious reforms to take effect, and for stability, both in the curriculum and Rwandan educational leadership:

> …there is need of stability in the curriculum. The curriculum keeps changing and it's very hard to…keep up with the pace and get stable and also measure the outcomes. There is also a need of stability in the leaders, in the leading team of the education environment. Leaders also keep changing and [it's] very hard when a leader is in place, they have a target they want to achieve but sometimes they get replaced before they have a time to implement their programme (Male Primary 4 teacher).

A few interviewees also advised on the value of greater consultation within the reform process. Specifically, they emphasised the importance of policymakers liaising with schools and teachers to solicit their views before introducing new changes. They also highlighted the need for officials to fully understand teachers' existing practices and challenges, as well as the impact of any reforms on children's learning. Similarly, one of the respondents addressed the value in sensitising pupils' parents and their broader communities:

> Another important thing I believe is needed is also training of parents or informing the parents about the new curriculum because when a student learns from the CBC and then goes home, there is a conflict because the parents don't know the new curriculum. They think that students are being too arrogant…parents should be informed about this new curriculum, also the local leaders should also be informed and trained about the new curriculum, but they are not yet (Male head teacher).

7.5.2 The Delivery of Teaching

In addition to factors relating to the organisation of teaching, many of the participants described particular barriers relating to the *delivery* of primary education in Rwanda, and how they could be addressed.

The first concerned physical infrastructure and its role within learning. Some interviewees commented on their school's lack of a proper playground or a large hall for undertaking extracurricular activities. A couple of respondents also noted how erratic or unavailable electricity could affect their lessons: "…we have to learn ICT but we don't have electricity in classrooms so that's [a] bit of a challenge" (Male Primary 4 teacher).

The vast majority of respondents, however, described a lack of appropriate learning materials as the greatest impediment to their teaching. Books, and accessing a sufficient quantity of the correct titles and *on time*, were especially problematic. Most of the teachers indicated that book shortages and even inadequate teaching guides were hindering their ability to support pupils in accordance with the competence-based curriculum:

> For example, today we have only 30 books that arrived in this week and the students are 233, who are supposed to use those books so that's a problem because the CBC also says that there are activities students should be doing at school but there are also activities that they should carry [out] at home, homework. But you cannot give a book to, 30 books to 200 students, it's impossible (Male head teacher).

Only one interviewee suggested that there were adequate, even plentiful, books in her school. In contrast to the other teachers, including respondents *in her own school*, she reported that her class had sufficient books to the extent that pupils could take them home. Such difference could suggest that there is variation in the availability of books within the same school depending on the particular subject concerned, in this case, mathematics.

In addition to the quantity of books, a couple of the participants commented on the appropriateness of official texts. For example, one respondent indicated that the content was too difficult for her pupils' actual level, while another noted the undue complexity of teachers having to navigate multiple versions of core materials issued by different publishers: "…it would be much better if there were a streamlined way of working with the publishers so that every school has the same book" (Female head teacher).

The timely delivery of books was also a common complaint across interviews. Teachers expressed frustration that books took a long time to arrive, often coming late and sometimes not until the second or third term in the year. As a result, the respondents argued for a better way of procuring their key texts, although the precise details were unclear:

> I would be happy to see changes in how we get learning materials. It's very difficult when you are teaching a class and you don't have learning materials. For example, I don't know the specific examples unless I go through a book on purpose and I can tell you 'this is not available, this is not available'. I think it would be better if the school had a way of supplying those learning materials to the class teachers (Female Primary 1 teacher).

Finally regarding learning materials, a couple of interviewees highlighted particular issues with using technology: "In the programme, we are supposed to be using computers in teaching ICT. But how am I going to teach ICT if I don't know myself how to use a computer" (Female Primary 1 teacher). One respondent indeed commented that in addition to the 'One Laptop Per Child' programme, she would also welcome a 'One Laptop Per Teacher' initiative. However, several participants noted that improved access to learning materials alone would not necessarily mean that teachers know how to use them effectively.

Many respondents therefore emphasised the importance of further training for all teachers to implement the competence-based curriculum as designed. They described it as something very new to them and proposed a more rigorous system for training teachers on nurturing children's skills, rather than their content knowledge, as well as a platform where they could ask questions when facing specific pedagogical challenges. In addition to teaching methodologies, several interviewees raised ongoing concerns regarding their familiarity with English and the value of increased instruction: "I would be happy to see…trainings specifically in the English language…when we are teaching, we keep switching between English and Kinyarwanda, it's because we are not fluent in the language" (Female Primary 1 teacher).

Two participants further noted the weaknesses of the current system in so far as teachers trained by the REB or other external bodies are expected to cascade their learning to their colleagues. Specifically, they queried both the existence of structures in schools to support such process, as well as the quality of the transmission:

> There is need of content training…for example, when two teachers get trained per school and they come back to train others, obviously the content they have captured is not transferred 100% to the other teachers, as they received it. And also those teachers who have received that half content, they don't transfer 100% of it to the learners, so there's something which is lost in between (Female head teacher).

Finally, half of the respondents and a majority of the *class* teachers reflected on their challenging work conditions, and how they could potentially impact on children's learning. They referred to the long working day with limited time for preparing lessons or gathering information relevant to their classes: "We teach so many hours and we don't get enough time to prepare the courses. By the time we finish the classes, we are very exhausted and the preparation time is very minimal. It's a very big problem" (Female Primary 1 teacher).

Similarly, many of the teachers described their low pay and remuneration, comparing them to volunteering or "working for God". Despite their commitment, the interviewees highlighted the need for financial motivation to both minimise stress and ensure that they can support their families. Two of them specifically referred to the challenge of getting *their own* children educated on public school teacher wages: "So you will find that, for example, a teacher will, in a public school will sacrifice much to take their children to a private school because we believe that that's where the quality is" (Female Primary 1 teacher).

Overall, the teachers outlined a range of barriers and impediments that they considered as hindering their ability to nurture their pupils' learning effectively. In some cases, they echoed the existing concerns of donors, journalists and academics, for example around double-shifting and the unavailability of sufficient textbooks, while in others they added fresh and valuable insight from the chalk face of Rwandan education (Abbott et al., 2015; Kanamugire, 2016; Moulton, 2016; Williams, 2016a). In all cases, however, they highlighted the importance of increased investment in basic learning to ensure that children achieve key cognitive competencies throughout the country.

7.6 Discussion

In 2011, a study funded by the United States Agency for International Development (USAID) conducted nationally representative research in 42 non-private schools across Rwanda (RTI International, 2012). Specifically, the team measured early reading and mathematics skills among Primary 4 and 6 children, and conducted observations to identify common practices in Rwandan classrooms. In many cases, such practices and teacher behaviours mirror those reported and observed in the present research, and therefore provide useful benchmarks for comparing behaviours in the case study schools.

First, the 2011 research revealed that “[i]nstruction across subjects and grades was almost exclusively whole class” (RTI International, 2012, p. 14), or involved Rwandan teachers writing on the blackboard and learners copying content into their notebooks. Empirical studies in other countries have similarly shown that even where teachers acknowledge the value of participatory pedagogies like group learning, such lip service does not necessarily translate into practical use in their lessons (Moloi et al., 2008; Mtika & Gates, 2010; Song, 2015). However, in the current research, most of the Rwandan teachers and especially at the Primary 4 level both reported *and demonstrated* evidence of children working in groups during their classes.

Indeed, the teachers interviewed described group work as furthering pupils’ cognitive skills through several mechanisms, via exposure to multiple perspectives, increased peer support and better collaborative learning, and these explanations accord with wider literature regarding the benefits of children working in groups. Based in a social constructivist epistemology, such group work allows pupils to share ideas, explore concepts and hear diverse viewpoints, in the process relating these different positions to their own particular perspective (Moloi et al., 2008; Tabulawa, 2003). Meanwhile, Kandemirci (2018) reports on the positive effect of collaboration on Turkish children’s creativity, and Hayford and Avoke (2011) emphasise the value of peer-assisted learning in groups of mixed ability to raise educational outcomes for all pupils. They suggest that such gains may be reciprocal and result from “a more appropriate use of language and a better understanding of particular difficulties… Furthermore, students improve their own understanding of concepts, knowledge and skills as they explain these concepts and support their peers" (p. 11).

These benefits do not, however, mean that using group work is without its issues, either ideological or practical. Tabulawa (2003) describes such participatory approaches as thinly veiled efforts by donors to promote the spread of Western values and neo-liberal ideals, like capitalism and democracy, under the guise of 'better educational quality'. Other studies have noted the potentially adverse effects of working in groups where high performers are dissuaded or impeded from achieving excellence because of time spent to help weaker learners (Mukama, 2010; Neo, 2003). Even in the 2011 USAID research, Rwandan teachers' use of group work was associated with *lower* learning outcomes, although this could be explained by a variety of reasons:

> An observation that a teacher was focused on small groups was not necessarily an indicator of students doing small group work. It may simply have indicated that the teacher was directing the lesson to only a fraction of the class rather than the whole class… Because Rwandan teachers do receive training in child-centered [*sic*] instruction that includes use of small groups, the negative relationship…may also indicate that teachers are attempting, but are not properly assigning and managing, group work (RTI International, 2012, p. 19).

Similarly, such study only measured pupils' reading and mathematical abilities, but not the other diverse skills that may have been nurtured if the teachers had been using group work effectively.

In the present research, the lesson observations also raised a couple of queries regarding the Rwandan teachers' use of group work. First, and as noted in section 7.1.2, at least one of the teachers might have been *overusing* the approach, and in three lessons the teachers instructed pupils to work in pairs or groups on six occasions or more. In classes of under an hour's duration, such frequent use of group work could be viewed as tokenistic, whether for the sake of the observation or otherwise, or too rushed for learners to enjoy the real advantages of peer collaboration. Similarly, in some of the Primary 4 lessons, predominantly those with male teachers, there was a strong emphasis on pupils keeping quiet or silent during the classes. Although, of course, children were permitted to talk during periods of group work, this expectation of silence suggests that some teachers may not yet be comfortable with more participatory pedagogies or their new role as the facilitators of pupils' learning. In summary, many of the respondents appeared to recognise the prospective benefits of group learning but may not yet be using the approach to its best effect.

Second, the 2011 USAID study reported that learning aids like posters and flashcards were "essentially never used" and that while 60 per cent of teachers claimed to use textbooks, the observations revealed that actual use in Rwandan classes was considerably closer to zero (RTI International, 2012). In the current research, by contrast, the lessons observed involved fairly common and regular use of different learning aids. In some cases, these were handmade charts or flashcards, in others the teachers had brought household objects like cups or clothing from their own homes to make the lessons more relevant to the children's daily lives.

The situation regarding the use of textbooks was nevertheless very similar to the findings of the 2011 research and a subsequent nationwide survey which indicated that textbook usage in Rwandan schools remains low (Milligan et al., 2017). Teachers replied that they *and their pupils* used textbooks but such practice was not corroborated during the classroom observations. In each study, the respondents described ongoing challenges in the procurement and timely delivery of textbooks as major factors that affected their use.

However, at least two of the schools participating in the current research had seemingly well-stocked libraries or book stores with multiple copies of the same texts. In which case, there may be ulterior reasons for the teachers' responses and limited use of classroom textbooks. First, they may not have felt comfortable or confident to teach effectively using the materials, not least if the practice was unfamiliar to them, or a deviation from their own learning or teacher training experiences. Second, the schools and teachers might have viewed the books as being precious resources to be protected and preserved, rather than learning aids to be passed between children's hands (UNESCO, 2016; World Bank, 2010). Alternatively, the teachers may have had concerns about the textbooks' quality, reliability or linguistic suitability for their pupils (Milligan et al., 2017). Finally, the interviewees may have cited the procurement challenges either in the hope of attracting additional support for the school, or as a fairly well-known and widely publicised problem in the implementation of the competence-based curriculum (Kanamugire, 2016; REB & VVOB, 2018).

Beyond means of instruction and learning materials, the USAID study noted a few further aspects of Rwandan schools and classrooms in 2011 (RTI International, 2012). For instance, it described a high prevalence of double-shifting, which still appeared to be the case in 2018. In terms of classroom layout, however, most of the teachers observed during the current research had abandoned the ‘traditional’ arrangement of pupils by rows and now seated their learners around tables to facilitate easier group collaboration.

The present study also revealed certain wider findings of particular relevance to research on children’s cognitive development. For example, teachers in the lessons observed used positive rewards, such as clapping and giving ‘flowers’, and songs, games and physical energisers to keep their learners engaged. In this regard, Diamond (2014) discusses the importance of children feeling happy, supported and motivated to work flexibly and exercise their different executive functions as required. Conversely, she describes the deleterious effects of stress, perhaps associated with more negative forms of class control like corporal punishment, which can impede learners’ ability to direct their attention successfully. Likewise, music, dance, singing and sport, especially where children work in groups or teams, can challenge and thereby improve their executive functions, including their cognitive flexibility.

Outside the classroom, many teachers reported learners’ participation in clubs as an important means through which schools foster their creativity, innovation and problem solving. Although such groups and their operations were not expressly observed, clubs that promote or protect children’s broader physical or emotional wellbeing through song, dance or other positive activities may similarly contribute to their executive function development (Diamond, 2014). More practically, Kaliisa (2019) describes the rise and value of entrepreneurship clubs to encourage practical skills among Rwandan students for their future lives and livelihoods. Nevertheless, as noted in section 7.3.1, where schools operate multiple clubs in parallel, pupils may have to choose to learn about one important issue, such as sexual health or environmental sustainability, to the exclusion of another. There is also the risk that topics addressed by clubs may be perceived as extracurricular, optional and therefore inconsequential or insignificant within the wider scheme of children’s learning and development.

More broadly, both teachers’ interview responses and their classroom behaviours aligned with practices and principles commonly associated with learner-centred education. The participants described and displayed efforts to use more active, experiential and inquiry-based pedagogies, often referring to the contents of external trainings by the REB, donor programmes or international NGOs like Wellspring and VSO. Indeed, the competence-based curriculum itself identifies learner-centredness as one of the core values underpinning its design: "The curriculum must address learners' individual needs, interests, abilities and backgrounds, creating an environment where learning activities are organized [*sic*] in a way that encourages learners to construct the knowledge either individually or in groups in an active way" (MINEDUC & REB, 2015, p. 4).

Most of the teachers appeared to agree with this approach, whether they truly perceived increased benefits for their pupils through learner-centred education, or were willing to defer to the pedagogical preferences of donor trainings or national-level policies issued by MINEDUC and the REB. A couple of interviewees even commended learner-centred methods as easing pressure on teachers by reframing them as the facilitators of children's learning: "The first thing I would say is to thank the person who decided to bring the CBC because it reduces the teacher's workload…because in the CBC, pupils work more than the teacher" (Female Primary 4 teacher). However, an informal conversation with the school-based mentor in one school indicated that there was still some latent opposition, with certain teachers resistant to change and only using learner-centred approaches during class inspections and lesson observations. It was unclear from his comments whether such teachers' reluctance arose from the additional effort and workload required to adopt the new practices, more general reform fatigue or because they feared being held accountable for pupils' lower outcomes while they settled into the new approach (Hopfenbeck et al., 2015).

Many of the challenges that respondents described similarly accorded with wider literature on the difficulties of implementing learner-centred education in low-resource settings. Studies by Schweisfurth (2011), Mtika and Gates (2010) identify large class sizes and constraints relating to infrastructure, learning materials and teachers' capacity as the main impediments for schools trying to use learner-centred methods in lower-income countries. Likewise, Song (2015) highlights poor working conditions among Cambodian teachers as limiting their time and energy to implement learner-centred approaches effectively:

> …teachers barely had any time for producing materials because they had to do a second job to supplement their small salary…[t]hey are consumed with how to

> supplement their meager [*sic*] income and how to deal with the poor classroom conditions, leaving them little time to study the ministry guidelines (pp. 42–43).

Regarding cognitive flexibility specifically, lesson observations in the present study revealed numerous mechanisms through which Rwandan pupils may be learning to switch and adapt. Through regular transitions in language and activity, and occasional changes in rules, children may be improving their ability to respond to shifting circumstances. Similarly, by working with different pupils in mixed groups, boys and girls, faster and slower learners, children may gain exposure to multiple perspectives, both conceptual and physical. In a mathematics lesson, for example, the teacher explained to a pupil that the rest of the class would be unable to read his answer unless he stood to the side of the blackboard as he wrote.

However, there were several occasions across the observed lessons, particularly in social studies classes, where teachers missed potentially valuable opportunities to explore more diverse perspectives or to use group learning to its best effect. For instance, in a class on the difference between needs and wants, there was dissent among pupils on how children's play and education should be properly classified. Rather than allow the learners to argue or debate why they could be categorised as either a want or a need, the teacher moved on quickly to consider other less contested items.

Follow-up discussion during the interview shed little additional light on the teacher's response. She referred to her textbook as the source of the classifications and mentioned the limited time as constraining their scope in the lesson for more nuanced collective analysis. Whether she saw value in encouraging a pupil debate or felt confident to facilitate such a discussion was also unclear. A further, more critical, explanation might similarly suggest a reluctance to deviate from the 'correct' responses of the textbooks, either because this could disadvantage learners in formal assessments or open other opportunities for pupil dissent.

To conclude and answer RQ4, the participating schools and teachers appeared to use a range of strategies to foster their children's cognitive competencies. Within the classroom, precise methods depended on the level of the learners and the subject being taught, but often involved group-based exercises to encourage collaboration, at least among the older pupils. Teachers also used practical activities on issues such as nutrition, hygiene and agriculture, and physical aids, crafts and materials, frequently sourced from their own homes, to impress on children the relevance of their learning. Lesson observations meanwhile revealed teachers using songs, rhymes and games to engage their pupils, but minimal use of textbooks. Regular transitions between activities and repeated language switches might similarly have nurtured children's cognitive flexibility, albeit inadvertently and at a potential cost to their wider learning.

Outside the classroom, respondents indicated nurturing learners' skills for adaptability through their participation in extracurricular clubs, assemblies and *itorero* civic instruction. The teachers also described efforts to enhance their own pedagogies through collective lesson planning, formal trainings and reciprocal observations. Finally, the participants shared their views on particular changes that they thought might help them to better foster their pupils' competencies. These included increasing lesson times, reducing class sizes, improving access to textbooks and reform consultations, more rigorous trainings for all teachers, and enhanced working conditions.

Overall, the practices and behaviours witnessed confirm a collective Rwandan shift towards more learner-centred pedagogies, notwithstanding the existence of numerous ongoing constraints which impede teachers' ability to implement them effectively. However, for reasons including time, cost and language considerations, I did not probe particular interview responses nor directly observe certain activities, like school clubs or teacher collaborations. Several questions therefore remain regarding specific aspects of Rwandan education, how it supports or otherwise impacts learners' creativity, innovation, problem solving, and wider cognitive flexibility, but these could comprise the focus of further research in the future.

CHAPTER 8 – CONCLUSIONS

Rwanda is changing, and fast. Since the devastation of the 1994 genocide, the country has seen rapid economic growth and ongoing social reconstruction (Knutsson, 2012). Kigali now boasts skyscrapers, malls and an expansive modern convention centre, while Thomson (2018) reports visitors falling in love with the capital's "clean streets, renovated restaurants…[and] wireless hotspots" (p. 1). In light of such transformation, the government has introduced an ambitious competence-based curriculum to build national human capital and help Rwanda transition from a low-income agrarian-based economy to an upper-middle-income country by 2035 (MINEDUC, 2019). Such curriculum also highlights the importance of schooling that inculcates skills for adaptability, like creativity, innovation and problem solving, but to date little has been known about these competencies and their development within Rwandan education (MINEDUC & REB, 2015).

The preceding chapters have sought to investigate this issue using a psychological lens to focus on Rwandan primary school children's cognitive flexibility. Specifically, the study contextualised its measurement, examined its relationship with other learning outcomes and cognitive competencies, and explored the practices and behaviours through which schools and teachers foster its development. In this concluding chapter, I bring together the different threads of the mixed-methods research to identify the key findings, their contribution to the field and their implications for Rwandan education. To this end, the chapter starts with a brief overview of the study, its objectives, methodology and main results. The second section synthesises and discusses findings from the quantitative and qualitative data, while the third section acknowledges the various limitations of the inquiry. In the fourth section, I outline the main and original contributions to the field of child development while the fifth section describes the significance of the results, particularly in relation to further research and Rwandan educational planning, and the sixth section closes the thesis with a few final reflections.

8.1 Overview of Research

As indicated at the outset, cognitive flexibility appears to offer numerous benefits for learners, not least by enabling them to adapt to changing circumstances, understand different perspectives and think creatively 'outside the box'. For these reasons, and others highlighted above, this study aimed to explore the development of Rwandan pupils' cognitive flexibility within formal primary education.

To do this, I drew on a theoretical framework combining the EdQual model for educational quality and Bronfenbrenner's bioecological systems theory, as elaborated in Chapter 3 (Bronfenbrenner, 1979, 1986; Tikly, 2011). The empirical mixed-methods fieldwork was conducted over 4-5 months during 2018 in four public primary schools serving low-income households in two districts of Kigali. Trained Rwandan enumerators captured cross-sectional quantitative data on 306 pupils randomly selected from age-in-grade learners in both Primary 1 and 4 classes. Each child was assessed one-to-one in their mother tongue using adapted versions of two established psychological tests to measure their cognitive flexibility, namely the Dimension Change Card Sort (DCCS) and the Flexible Item Selection Task (FIST). Pupils were also assessed for their broader executive function, non-verbal reasoning and basic literacy skills, and surveyed with age-appropriate tools to ascertain information concerning their home situation and prior schooling experiences.

Following conclusion of the pupil assessments, I undertook semi-structured interviews and observations with four head and 12 class teachers to address the qualitative aspects of the research. In particular, I sought to explore teachers' perceptions and attitudes regarding pupils' cognitive competencies, while the lesson observations aimed to identify existing practices that could *potentially* enhance learners' cognitive flexibility. Table 8.1 below sets out the research questions, the chapter that addresses each one, and the key findings to answer the questions.

To address the overall research objective, however, and to better understand pupils' cognitive flexibility development in Rwandan primary education require pulling together the data and results from both the quantitative and qualitative strands of the study. The next section therefore explores this interaction and proceeds with a discussion on the key findings, the similarities and differences between the case study schools, and how Rwandan education interacts with particular aspects of cognitive flexibility.

Table 8.1 - Summary of Research Questions and Key Findings

Research Question	Chapter	Key Findings
1. How can Rwandan pupils' cognitive flexibility be measured during the course of their public primary education and what factors are associated with its development?	4	Distributions revealed that both measures, the DCCS and the FIST, showed reasonable overall reliability and variation, with a mix of primary pupils both able and unable to switch, and a range of scores among those that could. The tasks were also significantly correlated ($r = .35, p < .01$), indicating that they assessed the same underlying construct, but possibly slightly different aspects of cognitive flexibility. Regarding explanatory variables, learners' class grade was the strongest predictor but children attending schools in one particular district and Primary 4 pupils from single-parent families also performed significantly better on the cognitive flexibility measures than their peers, holding other variables constant.
2. How does the cognitive flexibility development of Rwandan public primary school pupils relate to their other cognitive competencies?	5	Multivariate regressions revealed that pupils' cognitive flexibility performance significantly predicted their non-verbal reasoning and executive function, and vice versa, but the exact nature of the association appeared to vary with the learners' age or grade. Between the tasks, the FIST showed stronger relationships than the DCCS with children's other competencies. By contrast, there was only very limited evidence of any significant association between the pupils' cognitive flexibility and their reading skills, either fluency or comprehension.
3. What are the perceptions and attitudes of Rwandan public primary school teaching staff regarding the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	6	Analysis showed that teachers considered skills for adaptability, such as creativity, innovation and problem solving, as conferring a mix of individual and collective benefits, fostering originality, self-reliance and independence in learners' everyday lives, and building more responsible citizens who can contribute to Rwanda's national development. All of the interviewees indicated the equivalence of competencies between girls and boys, men and women, but there was diversity of opinion regarding the relevance of context in shaping the development and use of such skills.
4. What practices or behaviours are Rwandan public primary schools using to enable the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	7	Within the classroom, teachers used group-based exercises to encourage collaboration and a range of techniques, learning aids and materials, often sourced from their own homes, to impress on children the practical relevance of their learning. Regular transitions between activities and frequent switching between English and Kinyarwanda might also have inadvertently fostered pupils' cognitive flexibility. Outside the classroom, teachers reported learners building their cognitive competencies through participation in extra-curricular clubs, assemblies and *itorero* civic instruction. They also described efforts to enhance their own pedagogies through collective lesson planning and peer observation, to thereby foster their children's development.

Source: Primary data, 2018.

8.2 Discussion of Findings

8.2.1 Combining Methods

Mixing research methods offers numerous benefits in terms of increasing data depth and rigour. As outlined in section 3.4.1, such approach can access multiple, complementing or divergent views on the same phenomena, compensate for the weaknesses of one particular design, or corroborate the credibility of one set of findings (Venkatesh et al., 2016). In the present study, the choice of methods, both quantitative and qualitative, was driven primarily by the research questions and intended to provide as complete a picture of cognitive flexibility among Rwandan primary pupils as possible.

Specifically, the study adopted a post-positivist stance, a middle ground between the opposing epistemologies of positivism and interpretivism (Johnson et al., 2007). To date, cognitive flexibility as a psychological construct has been investigated through positivist scientific inquiry involving quantitative instruments and assessments. However, the educational processes through which schools foster and shape children's cognitive competencies, and the *rationales* for those behaviours, can only be properly understood through the perspectives of the people involved in such practices. The study therefore combined both approaches to address the different but complementary research questions, in each case also using different methods with different types of school respondent.

As such, the quantitative and qualitative strands were not intended to achieve convergence or corroboration, but rather to increase the breadth and understanding of factors related to children's cognitive flexibility development. Without the quantitative assessments, the study would have learnt nothing about Rwandan pupils' *actual* cognitive flexibility in Primary 1 and 4, and its interaction with other learning outcomes and household variables. Without the qualitative methods, the research would have shed light on Rwandan learners' cognitive development, but offered little insight on the practices and processes in schools that support it, and how they might be improved. In this respect, the study shares similar characteristics with evaluations where "quantitative methods…[are] used to assess program [*sic*] outcomes, and qualitative measures to assess implementation" (Greene et al., 1989, p. 269).

Within each strand and tradition, however, the research used multi-methods to complement and triangulate the findings (Venkatesh et al., 2013). In particular, interview responses and behaviours observed in lessons provided multiple perspectives on the same phenomena, such as teachers' use of textbooks or children's participation in group-based exercises. Integration of such data was feasible through analysing both interview transcripts and observation narratives as a combined dataset in NVivo.

Use of mixed methods similarly accorded with the theoretical framework that underpinned the study. As described in section 3.3, the research drew on the largely top-down EdQual model for educational quality, many aspects of which could be explored through the qualitative teacher interviews and lesson observations (Tikly, 2011). This was balanced with Bronfenbrenner's bioecological systems theory, a more bottom-up and child-centred model for development which guided the quantitative methods generally, and the pupil surveys in particular (Bronfenbrenner, 1979, 1986).

Between methods, the dominance afforded to one approach over the other represents an important concern in various literature on mixing paradigms (Johnson et al., 2007; Tashakkori & Teddlie, 2010; Venkatesh et al., 2016). In this respect, I sought to ascribe them fairly equal status, recognising the contribution of each aspect to the overall study. The timing and sequencing of each component was similarly driven by largely pragmatic considerations, often relating to the practicalities of data collection and analysis, rather than philosophical reasons. For example, pupil assessments took place first to avoid teachers changing their behaviours to prepare their learners, and because of the significant time and resource demands[53] of gathering developmental data with children in multiple schools. Likewise, the quantitative and qualitative analyses took place sequentially but could have been undertaken in parallel, as the findings were synthesised in the final stages of the study.

Only the selection of teachers for interview and observation *necessarily* took place after the pupils had been sampled. As outlined in section 3.5.2, teachers from the relevant grades and subjects were purposively chosen to maximise the number of children assessed in their classes. Initially, I had hoped to draw inferences between learners' performance on the cognitive tasks and their behaviours in lessons but, as described in section 7.1, the large Primary 1 and 4 cohorts in some schools meant that there were too few assessed pupils in any one lesson to conduct additional meaningful analysis.

Notwithstanding this limitation, there were several common issues that emerged from the different methods, the quantitative and the qualitative findings, as the next section explores in detail.

8.2.2 Cross-data Themes and Findings

Across the datasets, I identified numerous themes relating to Rwandan basic education and children's cognitive flexibility development that bridged two or more research methods. These

[53] In addition to time spent on actual assessments, this included programming tablets, training enumerators, recruiting schools and various other associated logistics.

included poverty and disadvantage, inclusive pupil collaboration, student leadership within classroom groups, and participants' use of language.

First, evidence of some learners' poverty and hardship was apparent throughout the school visits and the lesson observations. Many children wore patched uniforms, tatty clothing and scruffy flip-flops or other open-toed footwear. Several interview respondents also highlighted the difficult conditions affecting their pupils' learning, and their lives more generally:

> Some come from very poor families, some do not have parents. Some even live on the street…there are even children who come from this school and after class they go sell things in the market so that they can be able to live, to survive (Female Primary 1 teacher).

Other challenges described included parental drug use, hunger, malnutrition and illness. Indeed, in a few classes learners were excused or excluded from participation in the lesson on account of being sick.

Such disadvantages were corroborated by the pupil survey data. Of greatest concern was the 39 per cent of children who reported not having drunk anything before coming to school that day, 41 per cent of whom were attending afternoon lessons. Similarly, 32 per of the learners indicated that they had not eaten any food before school, of whom 15 per cent were surveyed during the afternoon session.

However, in contrast to literature on the adverse effect of poverty on children's development, data from the present study showed a mix of associations (Clark et al., 2013; Grantham-McGregor et al., 2007; Sarsour et al., 2011). For example, the 58 pupils who reported living in more stressful households performed significantly worse on the measure for non-verbal reasoning compared with their peers, 39 per cent of a standard deviation lower, even after controlling for other variables. Among these respondents, the Primary 4 subset of learners also showed reduced scores in terms of their reading comprehension.

Of greatest interest though is the finding that Primary 4 pupils from single-parent households performed significantly better on the cognitive flexibility measures than their peers from two-parent families, 29 per cent of a standard deviation higher, even when holding other factors constant. This is notwithstanding the fact that such children reported living in more basic houses, eating fewer protein-rich foods and experiencing greater levels of domestic stress. As noted in section 4.4.2, this directly conflicts with the results of research by Sarsour et al. (2011) in North America, but could provide evidence of disadvantaged Rwandan children displaying increased adaptability borne out of resilience and necessity. Such a finding would accord with several studies with learners in both high- and low-income contexts. For example, Mittal et al. (2015) found higher levels of shifting among American adults whose young lives had been characterised by uncertainty and unpredictability, while Dahlman et al. (2013) discovered greater creativity and ingenuity among Bolivian street children than their housed but also impoverished contemporaries. Most recently, a cross-cultural study by Howard et al. (2020) also revealed higher levels of cognitive flexibility among disadvantaged learners in South Africa compared with more privileged children from different backgrounds in Australia.

Aside from flexibility, poverty among Rwandan students is nevertheless likely to affect their wellbeing and thereby impact their cognitive development (Diamond, 2014; Sabates & Yardeni, 2020). Both Berry (2015) and Williams (2019) describe the major ongoing challenges faced by poor learners trying to complete their secondary education. Similarly, Pells (2011) critiques the national rhetoric that promotes nation building and self-reliance by pushing responsibility onto private citizens while ignoring the practical difficulties in their daily lives. She suggests that "[t]his highlights the government's problematic emphasis on 'children as the Rwanda of tomorrow' rather than children as the Rwanda of today" (p. 83). In which case, cognitive flexibility and the related skills of creativity, innovation and problem solving may offer important long-term benefits for Rwandan individuals and society at large, but meeting short-term needs for basic survival nevertheless remains a pressing concern for many learners.

Second, complementary data from the interviews and observations regarding pupil collaboration confirmed the equivalence of learning across the genders, and the inclusion of different types of children. As outlined in section 6.4.1, every interview respondent emphasised the equality between girls and boys and the relevance of cognitive skills for *all* pupils: "I think they're applicable in the same way, regardless if it's a boy or a girl, because I believe that what a boy can do also a girl can do" (Female Primary 4 teacher). In addition, several teachers sought to dispel previous notions about children with disabilities or the labelling of learners as 'fast' and 'slow', highlighting the inclusiveness of their practices.

Evidence from the lesson observations indeed revealed many pupils, especially in Primary 4 classes, working in groups of mixed gender. This at least partially corroborated the interviewees' responses about the equivalence of girls' and boys' learning. Several teachers also described children undertaking exercises in groups of mixed ability, but such claims were not overtly apparent from the observations. Similarly, although group work was not without its challenges, some of which were set out in section 7.6, the pupils seemed to be working relatively independently of the teacher and potentially supporting one another. This could confirm the perceived benefits of self-reliance and responsible cooperation, which numerous respondents ascribed to the skills of *guhanga udushya*, *ubudasa* and *kwishakira ibisubizo*, creativity, innovation and problem solving.

Related to learner collaboration and notwithstanding the inclusion of different children, half of the class teachers interviewed and observed used some mechanism for appointing pupil leaders or representatives within classroom groups to keep learners on task. However, the drivers and rationale for this approach remain unclear. On one side, it could reflect best pedagogical practice as advocated in teacher trainings by the REB, international NGOs or other donor programmes. Alternatively, such pupil leadership could rather represent an artefact of Rwandan culture and a recreation of the country's wider social hierarchies. Thomson (2018), for example, outlines the elaborate structures and systems of organisation that pervade all strata of Rwandan society from the government, right down to the "*umukuru*, four-person village-level committees responsible for governing between 50 and 200 households" (p. 204). As such, the appointment of leaders within classroom groups could introduce and reinforce national hierarchies at the lowest level of school interactions. Similarly, the repeat appointments of 'faster' learners could exacerbate differences between pupils where one voice or perspective in lessons carries greater weight than the others.

Finally, the teachers' use of multiple languages could have implications for the children's cognitive development. As indicated in section 2.2.4, some previous studies have suggested a positive association between bilingualism and learners' executive function, in particular their cognitive flexibility (Bialystok & Viswanathan, 2009; Diamond, 2016). However, in the current research, the quantitative data showed no evidence of any such relationship, and no significant difference between the cognitive flexibility scores of the monolingual pupils compared with those who claimed to speak multiple languages at home.

In fact, recent literature on the topic reveals that the issue remains contested. A study by Nichols, Wild, Stojanoski, Battista and Owen (2020) with over 11,000 participants similarly found no consistent or material cognitive advantage for bilinguals on the relevant measure: "The effect sizes indicate that being bilingual explains less than 1% of the variance in all significant results; for example, bilinguals outperformed monolinguals by a standard deviation of 0.05 on Digit Span" (p. 558).

Within Rwandan classrooms, bilingualism is nevertheless a necessary reality. Nearly all of the teachers observed used at least some mix of English and Kinyarwanda throughout their lessons. Although the sample size of reported multilinguals was small (n = 18), all of the Primary 4 learners in the case study schools would likely have had a minimum understanding of English in addition to their Kinyarwanda mother tongue. In which case, this knowledge and the advantage it confers over Primary 1 children could, at least in theory, account for some of the difference in cognitive flexibility performance between the two cohorts.

Even 10 years after Rwanda's initial educational language reform, numerous interview responses highlighted the ongoing challenge of teaching in English. Several participants reported lacking confidence and emphasised the need for further training. Beyond teachers, instruction for young children in a language aside from their mother tongue is typically associated with adverse impacts on basic learning and can create a perception of education as unduly difficult or complicated (Brock-Utne, 2001; Trudell & Schroeder, 2007). Whether Rwanda will ever achieve a full transition to genuine bilingualism, how long the switch will *really* take and the interim cost to pupils' learning remain open questions (Williams, 2019). However, if research on the psychological benefits of multilingualism can be believed, and Rwandan teachers continue to use both languages in their lessons, the country's policy of bilingual education may yet offer a silver lining in terms of learners' cognitive flexibility development.

To summarise, findings from the quantitative and qualitative analyses combined offer valuable insights regarding children's cognitive flexibility development within Rwandan primary education. In particular, survey responses and teacher descriptions highlighted the daily challenges facing many pupils, but also the relationship complexities whereby older children from single-parent families displayed better cognitive flexibility than their peers from two-parent homes. Despite few reports of household multilingualism, the lesson observations revealed the full extent of bilingual primary instruction, which may compromise early learning in the short-term but possibly foster greater long-term cognitive flexibility for pupils who can manage the switch. Similarly, data from the different qualitative methods, the interviews and observations, corroborated teachers' claims about inclusive classrooms but also raised questions about the wider implications of pupil leadership.

8.2.3 Case Study Schools

In addition to the synthesis of mixed-methods data, the selection of four schools as microsystems and cases within the study suggested value in identifying the similarities and differences between them.

First, regarding infrastructure, there were several differences in the tangible facilities available at each of the four schools. Full details of the amenities at each site are set out in Appendix 3, but the main physical difference between the schools concerned the relatively smaller campus occupied by School 3. Unlike the other schools, School 3 had a compact unpaved playground and seemingly no designated library or computer room. Within the classrooms, there were also discernible differences, specifically the larger class sizes in School 3, where both Primary 1 and 4 pupils were seated in rows, rather than clustered into groups.

Observed pedagogical practices were nevertheless largely the same across the four schools. In most lessons, teachers used clapping and 'flowers' as rewards to encourage their learners, practical teaching aids including charts and props, and a mix of plenary instruction and group-based exercises, particularly among the Primary 4 pupils. Teachers described taking part in various internal and external trainings, with schools in Gasabo district enjoying regular support and coaching from the Wellspring Foundation.

Regarding child assessments and outcomes, there was no clear or consistent pattern of performance. Pupils in the two Gasabo schools scored significantly worse on the cognitive flexibility measures, at least at the Primary 4 level and even after controlling for other variables, but they displayed higher average oral reading fluency and read more words correctly per minute than both schools in Nyarugenge district. Overall, there were differences between individual schools on specific tasks and assessments, but no learners in any one school repeatedly performed better on all measures than those in another school.

By contrast, there was a more consistent pattern of responses within the survey data. In particular, children in School 2 regularly reported household behaviours and characteristics associated with higher levels of SES. For example, they indicated eating more meals per day, greater consumption of meat and fish in their diet, and an increased prevalence of literacy within their families. Pupils' responses across the remaining three schools were generally much more comparable. Of further interest, all of the children that refused to take part in the research, whether declining to participate in the assessments or moving seats to avoid being recorded during the classroom observations were studying at School 2. This could suggest not just higher levels of SES among its pupils, but also a greater degree of child agency, confidence and empowerment.

Finally, I observed differences between the schools during the recruitment phase in terms of how the school management made its decisions. In two of the schools I was invited to present details of the proposed research to the principal and a combination of Primary 1 and 4 teachers. They then asked questions before discussing whether the study should proceed with their pupils and whether the assessments represented a legitimate use of their learners' time. In the other schools there was no such consultation, but these differences provide some insight into the tone of the school environments and the teachers' appetite for dialogue and even dissent. Indeed, this tolerance for multiple perspectives among colleagues arguably set a precedent with implications for certain aspects of children's cognitive flexibility.

8.2.4 Rwandan Education and Cognitive Flexibility

As indicated in section 2.2.1, this study explored Rwandan pupils' cognitive flexibility development using its broad definition as including "creatively 'thinking outside the box,' seeing anything from different perspectives, and quickly and flexibly adapting to changed circumstances" (Diamond, 2014, p. 206). Findings from the qualitative data in particular suggest various differences regarding how schools' practices and behaviours may support these three components.

First, teachers' interview responses highlighted several ways in which they sought to promote their learners' creativity and encourage them to think 'outside the box'. For example, they described using craft-based exercises, songs and games whether in lessons or through clubs to foster their children's originality. Similarly, the observations revealed regular classroom transitions, most frequently between activities and languages, which required pupils to switch and adapt to rapidly changing circumstances. However, nurturing learners' abilities to identify and understand multiple perspectives appeared to present a greater challenge. Although teachers described the value of group work specifically as a strategy for children to learn from one another and to hear diverse viewpoints, in practice there were few if any opportunities for pupils to discuss or explore differences in their opinions.

Teaching history in Rwanda has long been controversial for this reason. Numerous studies have emphasised the political sensitivity of Rwandan history education, both content and pedagogy, given the country's past tensions and violent conflict (Freedman et al., 2008; Hodgkin, 2006; McLean Hilker, 2011a, 2011b). Many have criticised the government's efforts to propagate a sole historical national narrative, whether through classroom lessons, *itorero* or *ingando*[54] training camps: "In promoting a singular version of Rwandan history, the policy of national unity and reconciliation fails to acknowledge the multiplicity of historical interpretations (and individual lived experiences) that constitute Rwandan history" (Thomson, 2011, p. 337). Similarly, teaching methods could have implications for learners' skill development:

> The pedagogy adopted thus far by the government is counterproductive. The construction of one unchallenged history, which the population has received from above rather than participated in creating, allows no capacity for critical thinking and independent analysis on the part of those being educated (Hodgkin, 2006, p. 205).

Encouraging children in Rwanda to see different perspectives appears to remain a delicate proposition. The new competence-based curriculum has moved away from more colonial models of education to embed learning that *Rwandan* society has reason to value, whether this comprises relevant capabilities, customs or viewpoints (Sen, 1999; Tikly & Barrett, 2011; Tikly & Bond, 2013). In terms of history, the national government like most countries worldwide wants to frame its narrative in a certain positive light, not least to promote unity, harmony and consensus in the future. However, there seems to be limited scope and space for pupils to really

[54] *Ingando* camps were established soon after the 1994 genocide and provide a centralised system of training which includes military exercises and cultural learning (Purdekova, 2014).

hear, analyse and understand contrasting perspectives. In turn, this could affect other aspects of learners' cognitive flexibility, the freedom to be creative and think 'outside the box', and thereby their ability to switch their behaviours and adapt to changing circumstances.

Studying pupils' cognitive flexibility in Rwanda nevertheless presented various challenges. The next section therefore examines the research limitations and their relevance in detail.

8.3 Limitations

Section 8.2.1 above highlighted my use of multiple and mixed methods to increase the completeness of the study and thereby maximise the strength of its findings. Notwithstanding these efforts, various methodological and practical factors imposed limitations on the research generally and with respect to the quantitative and qualitative datasets specifically.

First, the study focused only on public primary schools in relatively urban areas of Kigali. As such, it offers little insight on the experiences or cognitive flexibility development of pupils in Rwanda's more rural areas. Findings concerning children's competencies, teacher practices and schools' access to resources such as books, ICT and teacher training cannot be generalised beyond the narrow urban context of the capital city and may be very different in towns and smaller cities, as well as in rural settings (Rose & Alcott, 2015; Williams, 2017). Similarly, although the pupil surveys sought to ascertain and thereby control for certain household behaviours, like reading habits and private tuition, the research did not capture information on several non-formal channels for learning, for example community-based programmes and after-school activities, which can also contribute to pupils' cognitive skill development (Sabates & Yardeni, 2020).

Second, language posed a major challenge. For instance, it was critical that children were assessed in their mother tongue so I worked with both translators and enumerators to ensure that the task instructions were clear, age-appropriate and suitable for consistent administration. However, my limited knowledge of Kinyarwanda impeded my ability to assure the quantitative data quality and there was still the possibility that specific words were mistranslated or instructions were misunderstood (Squires, 2009). Likewise, I only observed classes conducted in English but missed the content of interactions where the teachers switched into Kinyarwanda or pupils worked in small groups. For the same reason, I was also unable to follow up the operation of clubs or observe *itorero* training sessions *in situ*.

Across the interviews, observations and surveys, there was a risk that participants were giving socially desirable responses or changing their behaviours as a result of the study (Schulz, 2005). For example, as described in section 7.2.3, several teachers reported using textbooks in their classes, but such practices were little used in the lessons observed. Reactivity and the Hawthorne effect might similarly have prompted teachers to use approaches like group work differently or more frequently than usual (Cohen et al., 2015; Robson, 2011). Participants may also have given particular responses to try to attract sympathy or support, if they were embarrassed by the truth, or where they thought that the research team wanted or expected to hear certain answers. These considerations indeed highlight the relevance of positionality, both mine in relation to teachers and that of the enumerators with pupils, which could have affected or influenced the different responses given.

Related to this was the challenge of capturing reliable and valid data from such young children. Collecting accurate information on the pupils' ages was particularly difficult. Less than half of the learners indicated ages that corresponded with the school registers and there were often mismatches between the ages and the birth dates provided by the pupils[55]. Other studies on African children's development have reported similar inconsistencies between caregiver and school records and so the challenge is clearly not unique to Rwanda (Mwaura et al., 2008; Wan et al., 2017).

Issues around task dimensionality might also have affected the learners' performance. As explained in section 3.6.3, children from low-SES households may be less familiar with stimuli like books and photographs and therefore achieve lower scores on two-dimensional test measures (Zuilkowski et al., 2016). In the current study, although the pupils sorted and matched physical cards on the two cognitive flexibility tasks, the images on such cards were two-dimensional and this could have prejudiced their overall performance.

Specific aspects of the quantitative data and their collection may similarly limit the weight and importance of the findings. First, the data are cross-sectional and while they allow analysis to

[55] In such situations, I used the age in school records as there was sometimes wide variation in the pupil responses.

identify differences between individuals and cohorts, they cannot be used to attribute causality or to make inferences on children's *actual* development (Gruijters & Behrman, 2020). Second, the sampling approach gave rise to high collinearity between pupils' ages and their class grade which prevented me from isolating the effects of schooling from those of natural maturation. Third, the study did not capture data on children's emerging numeracy, which other studies have shown to be associated with executive function (Clark et al., 2010; Wolf & McCoy, 2019). Cognitive flexibility in particular could hold significance for learners' numeracy by enabling them to make mental links between the word 'four', the character '4' and the notion of four items, as opposed to three or five. Indeed, children's ability to switch and discern patterns may be even more pronounced where they learn mathematical concepts and functions in a language other than their mother tongue.

Fourth, certain data from the learner assessments did not meet all assumptions for parametric analyses, such as the normality of sampling distributions, and so face value interpretations must be treated with caution. Related to this, the use of adapted measures for assessing cognitive flexibility among Rwandan learners for the first time also gave rise to some additional limitations. As indicated in section 3.6.3, neither the DCCS nor the FIST had been previously validated in the country and only the former had seemingly been used with young children in a couple of other sub-Saharan African contexts (Howard et al, 2020; Talwar et al, 2011).

Between the measures, the DCCS arguably represented a simpler and more straightforward assessment of pupils' cognitive flexibility than the FIST. While the former included explicit instructions on how the learners should sort the cards, the latter drew on children's wider skills, not least their non-verbal reasoning, to match the different boxes. This could explain the stronger association between pupils' FIST scores and their performance on other cognitive measures, but it also indicates a higher degree of task impurity and might account for the large number of children who failed the initial rounds of the assessment.

Capturing reliable data from the DCCS likewise proved easier when working across multiple languages. Learners' responses to sort the DCCS cards against the green goat or yellow motorcycle were clear and unambiguous. By contrast, pupils' FIST scores required that they both match similar boxes *and* provide an explanation for their choices. This placed greater demands on the enumerators to interpret and evaluate the children's justifications, and reduced my ability to assure the quality and accuracy of the resultant data.

Overall, using both the DCCS and the FIST increased the construct validity of the study by collecting data on different aspects of cognitive flexibility. While the former assessed learners' sequential switching, the latter tapped their ability to consider multiple factors simultaneously. In both cases, the measures performed as expected and displayed the anticipated distributions across the primary cohorts. However, by including the more advanced trials, the DCCS also provided data on pupils' concurrent cognitive flexibility as they attended to different card dimensions in parallel. Future studies in Rwanda and similar contexts may therefore do well to adopt the DCCS as offering a more adaptable, user-friendly and complete measure of cognitive flexibility than the FIST, at least where the more complex border rounds of the task are involved.

Beyond the cognitive flexibility assessments, the measures used for ascertaining pupils' literacy also presented further limitations. During the study design, I selected the EGRA and FARS as instruments validated in Rwanda that place children on a spectrum of reading progression, from letter identification to oral fluency and then full comprehension. As described in section 5.4.1, they worked well for the Primary 4 learners but only a handful of Primary 1 pupils could identify more than a few familiar letters. The prevalence of younger children performing at floor was not unexpected as most of them were right at the start of their formal education, however, the use of the EGRA and FARS across such a wide learning range arguably undermined the comparability of literacy across the primary cohorts. As such, the data offered valuable insights concerning the relationship or lack thereof between reading and cognitive flexibility *within* the Primary 1 and 4 samples, but any comparison *across* the groups must be treated with caution.

Several research limitations also concerned the collection of qualitative data. First, although there are conceptual linkages and overlaps between cognitive flexibility and the related skills of creativity, innovation and problem solving, they are not necessarily equivalent in Rwanda or elsewhere. In which case, teachers' responses in interviews regarding the latter competencies among pupils could not be treated as automatically relevant to their cognitive flexibility development.

Second, time pressures in interviews constrained the scope and space to probe some of the teachers' answers. Interviews typically took place at lunchtimes, break times or during teachers' free periods. While they were happy to take part, their time available was generally precious and this occasionally deterred me from asking further follow-up questions or requesting examples. The teachers already worked long days from 7am to 5pm and my imposition ate into their marking or lesson planning time. Likewise, use of an interpreter ensured an accurate account of the teachers' perspectives but sometimes curtailed the interview time. During the transcription process, I also noted several missed opportunities where I could have requested additional clarifications, but was unable to frame an appropriate question in the time available. This was particularly pertinent on occasions where there were mismatches between teachers' reported and observed behaviours and, for ethical reasons, I was keen to avoid any question that could be construed as critical, accusatory or disrespectful[56].

Finally, a seeming lack of *qualitative* research in the international literature on executive functions meant that there were no previously validated protocols for conducting lesson observations related to cognitive flexibility. This required me to take a broad and exploratory approach towards recording classroom activities and developing the inductive coding scheme. As a result, the lesson observations were driven more by theory than by methodological precedent.

Notwithstanding these limitations, the study offered valuable insights on various aspects of children's cognitive flexibility in Rwanda and executive function development in other lower-income countries. The next section therefore examines the original contributions and main argument of the research more closely.

8.4 Original Contributions and Argument

As noted in Chapter 2, research on learners' executive function and cognitive development has for many years focused predominantly on children in higher-income contexts, often based in Europe and North America (Dias & Seabra, 2015; Howard et al., 2020; Obradović & Willoughby, 2019). This narrow focus has both skewed accepted 'knowledge' by over-representing learners from Western and affluent countries, and overlooked the chronic effects of poverty, malnutrition and other disadvantages that limit the life opportunities of so many children worldwide (Grantham-McGregor et al., 2007; Schulson, 2020). More recently, however, there have been increasing studies to build evidence regarding learners' cognitive

[56] Example questions would have included why teachers did not allow pupils to use textbooks themselves or explore diverse opinions within the classroom.

development in lower-income countries, including in sub-Saharan Africa (Cook et al., 2019; Holding et al., 2018; Willoughby et al., 2019). This thesis adds to that growing corpus and seemingly comprises the first study of children's executive function in Rwanda.

More specifically, the research focus on cognitive flexibility in particular offers several significant and original contributions. First, while many studies have included switching or shifting tasks within broader research on learners' executive function, this study drew on the wider definition of cognitive flexibility by Diamond (2014) to place it at the centre of the inquiry. To do this, the research used both inductive and deductive measures of cognitive flexibility to explore its relationship with other competencies and outcomes, in addition to pupils' wider executive function.

Second, whereas most previous studies have emphasised the contribution of cognitive flexibility to children's traditional academic learning, namely their literacy and numeracy, this research recognised its value in its own right, as well as its relevance to wider aspects of individual holistic development, not least creativity, innovation and problem-solving skills (Zelazo et al., 2016). This focus is particularly important in Rwanda and similar lower-income countries that are working to build their national economies through increased entrepreneurship, adaptability and job creation.

Third, the two most prominent tools for assessing children's psychological development in diverse contexts, the MELQO and the IDELA, both lack any measure of cognitive flexibility in their current forms (Pisani et al., 2015; UNESCO et al., 2017). These omissions are concerning given the potential balance between cognitive flexibility and inhibitory control, discussed in sections 2.2.3 above and 8.5.2 below (Blackwell et al., 2014). The thesis however demonstrates that cognitive flexibility *can* be assessed in lower-income countries with existing measures from wealthier contexts, providing that they are adequately adapted for use in the particular environment (Obradović & Willoughby, 2019).

Regarding methodology, most research on cognitive flexibility has examined its development using quantitative approaches only in either home or school settings. Few if any studies, however, have employed *qualitative* methods or sought to explore educational practices that could be aiding its growth. Notwithstanding the limitations described in section 8.3 above, this research offers fresh insight by using mixed methods among different stakeholders in several schools for a more complete picture of Rwandan pupils' cognitive flexibility development.

In terms of analysis, many studies have examined cognitive flexibility as a binary outcome among young pre-school children. This typically categorises them according to their narrow ability or inability to switch between different rules, and has given rise to claims about cognitive flexibility reaching maturity as early as middle childhood (Deák & Wiseheart, 2015; Zelazo et al., 2016). By contrast, in the present research, I used proportional scores and multivariate analyses for a more detailed and granular understanding of older learners' skills along a spectrum of cognitive flexibility performance.

Finally, the study has highlighted the significance and potential application of child psychology in global efforts to promote and foster 21st century competencies. In this regard, the teacher interviews emphasised the importance of skills such as creativity, innovation and problem solving for all Rwandans to apply their learning, improve their lives and thereby contribute to their country's advancement. The thesis further argues that cognitive flexibility, comprising the ability to think creatively, adapt quickly and adopt different perspectives, provides a suitable framework for Rwanda and other similar countries to understand and support these valuable competencies.

Specifically, the quantitative analyses showed that cognitive flexibility can be measured in lower-income settings where it appears to improve beyond early childhood and throughout the course of primary education. Broader cognitive development evidenced through non-verbal reasoning and wider executive function seems to account for some of the change, but the data revealed no consistent relationship between Rwandan pupils' cognitive flexibility and their emerging reading skills. This finding is significant both because it contrasts with wider literature from higher-income contexts and because reading is so central to educational outcomes in sub-Saharan Africa and globally (Cartwright, 2008, 2009, 2012; UNESCO, 2005). The lack of association could ultimately be due to measurement issues, particularities of the Rwandan setting or factors outside the scope of the study, but certainly warrants further investigation in future research.

Already, Rwanda has introduced a competence-based curriculum to expand learning and promote children's more holistic development. The lesson observations also identified existing practices within Rwandan primary schools that may intentionally or inadvertently foster pupils' cognitive flexibility. However, this thesis argues that many such behaviours can be enhanced to ensure that learners leave school with the practical skills to avoid poverty and build more prosperous lives. Indeed, these hold implications for both research and educational planning in Rwanda, as the next section explores.

8.5 Research Implications

8.5.1 Future Research

International research on children's development and executive function has shown recent signs of diversifying its evidence base, even since this study began (Holding et al., 2018; Obradović et al., 2016; Willoughby et al., 2019). Further research with learners in Asia, Latin America and Africa will offer a more complete understanding of children's psychological and cognitive development worldwide and thereby provide a stronger scientific basis for policymaking in education and other child-focused sectors.

This study in particular has highlighted the value of greater research on learners' cognitive flexibility, not least given its relevance for the acquisition of more advanced 21st century skills. While studies on children's overall executive function may offer useful insight on how they build self-regulation, manage their behaviour to achieve prescribed goals and navigate early educational experiences, increased research on cognitive flexibility *and* over longer life periods could generate important knowledge for schools and education planners on how best to nurture creativity and problem solving among their graduates. Indeed, this reiterates a wider call for international researchers to "expand our methodology and conceptualization [*sic*] of cognitive flexibility to include more facets…and a broader perspective on [its] lifelong development" (Podjarny et al., 2017, p. 202).

As a first step in this process, both the MELQO and the IDELA should be updated to include one or more measures of cognitive flexibility[57]. This would both increase global data on children's basic skills for adaptability in different contexts, as well as signal the importance

[57] I note that in a study using the MELQO with young children in Cambodia, the DCCS was included as a supplementary measure of cognitive flexibility in addition to the other assessments (Berkes et al., 2019).

and relevance of cognitive flexibility over and above its contribution to more general executive function.

Cognitive flexibility could also provide a useful basis for education systems, both in Rwanda and beyond, to assess their pupils' early development and foundational learning for the acquisition of later life skills. At present, many systems only measure competencies like problem solving when students are older, literate and numerate, often as they leave primary school, enter secondary education or transition into the workforce. However, *earlier* assessment of cognitive flexibility as a building block for creativity and problem solving could ascertain whether children are on track to acquire more complex mental competencies in accordance with the competence-based curriculum, and at a stage when remedial actions could still be taken. In Rwanda and following this study, such process could now use the DCCS or the FIST to capture developmental data on learners within Kigali or across the country, for schools and teachers, or to advise on wider trends within the primary education system.

At a smaller scale, further research in Rwanda could address many of the limitations of the current study and thereby improve the strength of the findings. First, follow-up research to re-assess the same children several years later would offer longitudinal data on the pupils' cognitive flexibility and greater insight on their actual development. This could involve measuring the same set of competencies, including non-verbal reasoning, executive function and literacy, or supplementing them with data on additional skills such as learners' numeracy. Noting the potential relevance of dimensionality, tasks such as the DCCS could be converted into a three-dimensional format requiring learners to sort different blocks or toys according to their shape or colour. Data quality and administration consistency could be ensured by video-recording the learners' assessments and entering their responses afterwards.

Such a study could increase the reliability of the current research *and* future data through greater engagement with pupils' families and caregivers. Children's guardians, for instance, would be more likely to have accurate details of the pupils' ages and offer a more complete picture of household characteristics and influences, for example their highest level of education and recreational reading practices. The research could even involve measuring the executive function and cognitive flexibility of the caregivers themselves to explore any transmission of skills between the generations (Sarma & Thomas, 2020).

Several additional components could similarly build on the strengths of the current study. These could include qualitative interviews with the children to understand their perspectives and their involvement in non-formal learning, community programmes and household chores. Alternatively, further lesson observations with multiple Kinyarwanda-speaking observers per class could gain a more nuanced understanding of pupil-teacher interactions and how classroom activities may shape different learners' cognitive development.

More generally, the current research has raised other questions which could form the focus of new studies in Rwanda. These could examine the relationship between children's cognitive flexibility, executive function and school readiness as they transition into formal schooling and through the first few years of primary education. Other valuable research could compare the cognitive development of children in and out of school, or explore the effects of bilingualism among older primary pupils. Another interesting study would investigate the cognitive effects of *itorero* civic training, either in schools or through wider national programmes, to examine its impact on learners' creativity, innovation and problem solving.

Notwithstanding these knowledge gaps, the present research has several implications for Rwandan education, both planners and teachers today and in the future.

8.5.2 Rwandan Educational Planning

First, the findings underline the value of education systems that promote more diverse, holistic and inclusive learning outcomes among their pupils. Teachers described the importance of children building wider practical skills in addition to more traditional academic priorities for them to improve their lives and adapt to the demands of the 21st century. Similarly, the respondents acknowledged the multifaceted nature of learning and child development, and how different competencies could progress among different pupils at different rates: "I understand that every child is unique in their own way, for example a child can be good at English, and another one can be good at listening, and another one can be good at writing" (Female Primary 1 teacher).

This variation was corroborated by the inconsistent patterns of association between the cognitive competency measures. As shown in Table 5.18, learners' non-verbal reasoning skills were correlated with their global executive function at the Primary 1 level, but not among

Primary 4 pupils. Likewise, the lack of significant relationship between learners' reading abilities and their cognitive flexibility could imply that efforts to foster the former may not *necessarily* nurture children's skills for adaptability. Overall, such findings support the introduction of the Rwandan competence-based curriculum and suggest the value of greater investment to nurture all aspects of pupils' development, and not just literacy and numeracy.

Second, the quantitative findings regarding primary repetition emphasise the importance of good quality *early* education to lay solid foundations for children's learning in the younger years. Increased investment in widely accessible and high-calibre school readiness initiatives or pre-primary education could potentially secure the cognitive gains of Primary 1 repetition but without the need to delay pupils in their progression. Similarly, children in the study who reported attending pre-primary school achieved an extra 8 per cent of a standard deviation on the Tower of Hanoi for each year attended, holding other factors constant, $b = 0.08$, $p = .01$.

Regarding education more broadly, some of the policymakers met with before the main fieldwork frequently advised me to speak to their colleagues in other MINEDUC or REB departments. These comments highlighted the need for effective coordination across different components of Rwandan education, being a key responsibility of the REB. With the new curriculum in place and some teacher training underway, assessment remains a notable gap and the interview respondents often described generic practices like tests and examinations as means for monitoring pupils' progress. Although the assessment system is allegedly under review, final decisions around what is measured and how will send an important message to Rwandan educational stakeholders in terms of desirable outcomes and valued learning. Indeed, many other countries face a similar issue:

> …systems around the world still struggle with the lack of coherence between tests, assessments, curricula, students' learning and classroom practices. As policy makers gradually pick up the new buzz words of 'teaching for tomorrow's world' and '21st century skills', examination systems around the world continue to deliver exams that echo of the previous century (Hopfenbeck, 2018, p. 351).

Teachers themselves also play a critical role in translating assessment priorities and curricular expectations into pedagogical activities inside the classroom. Already, Rwandan educators are contending with the extra demands of the competence-based curriculum, notwithstanding the constraints of textbook unavailability, insufficient contact time and inadequate in-service training. Nevertheless, findings from the lesson observations identified several subtle ways in which teachers could adapt their existing practices to encourage their pupils' cognitive flexibility. These include providing space and opportunities, for example through open questions, group exercises or club discussions, for learners to think more creatively about subject content, or to explore and analyse different perspectives, perhaps framed through more informed use of the word 'why'.

Finally, and more generally, the study's focus on cognitive flexibility could have implications for the organisation of teaching in the lower years of Rwandan primary education. Specifically, two aspects of learners' cognitive flexibility would support the recommendation by a head teacher in the current research and a respondent in the 2012 study that children should be taught by one class teacher for each year of their initial basic education. Indeed, such an approach could arguably also address some of the wider challenges and concerns raised by numerous other teachers.

As described in Chapter 2, cognitive flexibility development appears to confer a range of important benefits, not least by scaffolding the acquisition of skills for adaptability, such as creativity, innovation and problem solving. However, as outlined in section 2.2.3, cognitive flexibility needs to be balanced with effective inhibitory control (Blackwell et al., 2014). With too much inhibitory control, children can appear rigid and unable to adapt, but with too much cognitive flexibility they become easily distractible and struggle to concentrate on the task at hand (Zabelina & Robinson, 2010).

Switching between activities also has a cost in terms of the cognitive effort required to achieve the change. Such costs are often calculated with reference to response time or accuracy, and occur even where the change is completely expected (Ellefson et al., 2006). The size of the cost can depend on factors including the difficulty of the new task, any previous practice and the new dimension being engaged in the case of psychological assessments.

Inside Rwandan classrooms, switches take various forms with teachers changing activities, languages and rules within an exercise. The teachers themselves also change depending on whether they instruct mathematics, English, Kinyarwanda or another subject. This structure came into effect in 2008 with the introduction of the *Nine Year Basic Education* policy, following which teachers have become subject specialists and rotate between classrooms throughout the school day (Honeyman, 2014; Williams, 2017). For one respondent, however, these additional changes between teachers every 40 minutes are unhelpful, distracting and counterproductive. As set out in section 7.5.1, she advocated for children learning with the same teacher across subjects for each year from Primary 1 to 3. Arguably, this approach would reduce pupils' switch costs in adapting to the new teacher and increase their mental capacity to focus on the lesson at hand.

There could also be additional benefits for both learners and teachers alike. Children would experience greater continuity within their 4-hour school day and more time to build rapport with one specific teacher. The teachers would also work with fewer pupils but have more time, admittedly over several subjects, to understand individual children's needs, strengths and difficulties, both in the classroom and at home. This could help to ease the pressure of teaching several hundred pupils in one day and would enable them to monitor and track learners' development across multiple domains rather than their performance in one specific subject.

For now, the *actual* relative merits of subject- versus class-based teaching remain unknown and an issue for Rwandan policymakers. Whether or not such a change and policy reversal would be desirable, feasible or politically palatable in the existing system rests with MINEDUC, the REB and teachers themselves, but this is an area that *could* warrant further investigation.

In summary, the study offers various implications for improving Rwandan education. First, the quantitative findings acknowledge the diversity of children's cognitive development, emphasise the importance of expanding pre-primary learning and highlight the need for greater resources, planning and training to implement the competence-based curriculum effectively. Second, the qualitative responses and lesson observations identify the value of aligning and strengthening assessment, and supporting teachers to use current pedagogies, like group-based exercises, to better learning effect. Third, the overarching framework which places pupils' cognitive competencies at its centre arguably suggests restructuring the earlier years of schooling to increase learner-teacher continuity and thereby maximise their classroom interactions. In reality, if or how policymakers and planners advance any of these areas will depend on multiple factors including resources, capacity and logistical feasibility, but in any case the research focus on pupils' cognitive flexibility provides a new lens through which to evaluate current educational practices in Rwanda.

8.6 Closing Reflections

Global events since this study started have highlighted the ongoing significance and relevance of skills for adaptability. Protracted conflicts and regional instabilities have fuelled migration that requires individuals and communities on all sides to accommodate a growing multiplicity of languages, beliefs and customs. Threats of irreversible climate change have risen up the international agenda while vulnerable communities in fragile settings contend with increasingly extreme weather patterns, droughts in one area and floods in another (Bayley, 2019; Ogando Portela & Pells, 2014). Most recently, the COVID-19 pandemic has prompted citizens on all continents to re-evaluate and reconfigure core aspects of their work, social and family lives.

Against this backdrop, a greater understanding of cognitive flexibility development among disadvantaged learners and historically under-researched populations may offer timely and valuable insight. For years, educational planners have sought to expand pupils' learning outcomes by introducing competence-based curricula, albeit with varying degrees of success (Cunningham, 2018; Gauthier, 2013; Tedesco et al., 2014). In parallel, psychology researchers have examined the intricacies of children's ability to switch and adapt, but largely within the privileged confines of certain cultural and economic contexts.

This study aimed to bridge these two fields and areas of inquiry by investigating learners' cognitive flexibility within Rwandan primary schools. By capturing data on both pupils' development and school-level behaviours, the research drew findings that may offer practical significance for Rwandan policymakers, teachers and NGO partners. These include the value of pre-primary education, the importance of holistic learning in addition to basic literacy and numeracy, and the ongoing difficulties around teachers' effective use of group work in their lessons.

Looking ahead, the global community needs to think creatively and flexibly to tackle our collective human challenges. Increased interaction between education planning and psychology research could aid this goal by supporting learners to think 'outside the box' today, and thereby become the problem solvers of tomorrow. In so doing, we may ensure that all children acquire the skills they need for adapting to life in the 21st century and a rapidly changing world.

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APPENDICES

Appendix 1 – Pilot Methods and Analyses

School Selection and Administration

The first pilot was undertaken in a private primary school on the outskirts of Kigali. Such school was selected for reasons of easy access and convenience, based on a pre-existing relationship (Cohen et al., 2015). The school benefits from the support of an international NGO and operates from a purpose-built facility in a neighbourhood of mixed affluence. Although the parents of most children are required to pay school fees, a number of pupils attend for free through scholarships based on family circumstances and low SES. These children comprised 18 per cent of the pilot participants.

The school also had three nursery level classes but these were not included in the pilot. Their existence could nevertheless imply that pupils in the primary school had a higher likelihood of having attended pre-primary education, which could have improved their performance in the assessments.

In total, 61 pupils from Primary 1 (26 pupils), 4 (25 pupils) and 6 (10 pupils) were assessed, comprising 33 girls and 28 boys. These comprised all pupils from Primary 1 and 4. A smaller sample for Primary 6 was used with participants selected based on their receipt of a scholarship, and thereafter stratified according to their academic performance. None of the children had been diagnosed as having any atypical behavioural or developmental condition. In accordance with the prevailing literature, pupil ages varied considerably within the grades at an average of 3.83 years' difference between the oldest and youngest pupils in each class (Sabates et al., 2010). Children were rewarded for the completion of each task with a sticker and although no pupil declined to participate, several learners ended particular tasks early. The measures and pupil scores are described in further detail below.

The assessments started with pupils in Primary 6 and worked downwards. Assessments were conducted in the school library and during initial rounds pupils were assessed one at a time. However, when the enumerators had become familiar with the process, two children were tested simultaneously at opposite ends of the library. The assessments were largely undertaken in Kinyarwanda, save for a few Kenyan children who requested to be tested in English. Testing lasted on average 52.62 minutes and concluded with the pupils answering a few questions on their prior schooling experiences and home situation.

During the first pilot and indeed the early stages of the research, my intention was to assess children's cognitive flexibility at three points in their basic education, hence the inclusion of Primary 6 pupils in addition to those in Primary 1 and 4. However, following the initial pilot, the sampling strategy was updated to focus on the younger years only. This would comprise Primary 1 pupils right at the start of their education and Primary 4 pupils who had typically completed 3 years of formal schooling.

This decision was driven by a mix of practical, ethical and theoretical reasons. First and foremost, Primary 6 pupils in Rwandan schools are typically preparing to sit their primary leaving examinations, high-stakes assessments which dictate progression (or not) into secondary education. Conversations with several stakeholders indicated that schools would be reluctant to release their Primary 6 pupils to participate in non-essential activities, not least because such distractions could risk doing harm by prejudicing learning opportunities at a critical point in pupils' academic careers. Secondly, by assessing children across a wider age range, there was the possibility of introducing unnecessary 'noise' in the data, not least the effect of unexpected and unobserved factors which could undermine the validity of the final findings.

Multidimensional Card Selection Task

As part of the first pilot, pupils were assessed using the Multidimensional Card Selection Task (MCST) outlined by Podjarny et al. (2017). This deductive task involves the pupil choosing a series of cards during several rounds which test the child's ability to recognise shapes, remember and follow basic instructions, and consider up to three card dimensions concurrently. Minor adaptations were made to account for the particular cultural context: pictures of cups replaced images of teapots during the first round, and cards were 'given' to photographs of people, rather than dolls, during the second round.

The assessment served as a useful warm-up activity and an opportunity for the enumerators to build rapport with the pupils. However, across the rounds and indeed the classes, performance levels were very high and even pupils in Primary 1 had few difficulties in selecting the correct cards. As a result, the assessment showed minimal variation within or across cohorts and revealed little in terms of pupil's cognitive flexibility development, concurrent or otherwise.

Children's high performance could have been due to a variety factors, not least their SES and the wealth of human, physical and financial resources available at the pilot school. Nevertheless, the ceiling effects suggested that the MCST was inappropriate for use with primary-aged children (having been designed for 3- and 4-year-olds) and the test was therefore removed from the main fieldwork battery.

Wisconsin Card Sorting Test

Pupils in the initial pilot were also assessed using the Wisconsin Card Sorting Test (WCST) developed by Grant and Berg (1948). This inductive measure taps several aspects of executive function simultaneously but has been used widely to examine cognitive flexibility and shifting abilities among both children and adults (Cragg & Chevalier, 2012; Jacques & Zelazo, 2001; Zelazo et al., 2004). During the test, participants are presented with 64 response cards which they must match against one of four stimulus cards, each depicting one red triangle, two green stars, three yellow crosses or four blue circles. Cards can be sorted according to their colour, shape or number, and after each match, the participant is advised whether the selection is correct or not. After a prescribed number of correct responses, however, the sorting rule changes and the participant must determine the new rule and place the successive cards accordingly.

In the pilot version, the sequence of cards was pre-ordained to reduce the demand on enumerators and to increase accuracy in administering the test. The rule changed every ten cards so that after a switch the pupil could place a few cards incorrectly and still achieve six or seven correct confirmatory trials, being the average number of reinforcing or confirmatory trials prescribed in the Grant and Berg (1948) protocol. Each assessment started with a trial round of 20 cards, following which pupils who had sorted a minimum of eight cards correctly progressed to complete the remaining 44 selections.

Descriptive analysis of the scores revealed results which were broadly as expected. Within each sample, there was considerable variation, with pupils in Primary 6 achieving a higher average of correct sorts than children in Primary 4, who in turn outperformed the pupils in Primary 1. However, challenges identified in administering the assessment revealed weaknesses in using the test among Rwandan school children, and reasons to exclude the measure from the main fieldwork.

First, the assessment placed considerable demand on the enumerators who needed to simultaneously track the placement of cards, check whether they had been correctly placed and then provide appropriate feedback to the pupil. This gave rise to scoring inaccuracies and errors, particularly when children continued to sort cards without awaiting the enumerators' responses. Second, many pupils, particularly from the Primary 1 class, seemingly misunderstood the purpose or operation of the test. Some of them appeared to place the cards at random, others failed to abstract or apply the rule even after one or two correct sorts. This failure was further evidenced by the selection of distractor cards. Within each class, but especially among the Primary 1 pupils, children paired cards that matched on *no* dimensions, for example two red circles against three yellow crosses. As Zelazo et al. (2004) describe:

> the origin of errors on this task is difficult to determine…For example, perseveration could occur after a rule change in the WCST either because a new rule was not hypothesized, was hypothesized but not selected, or was selected but not acted upon (p. 170).

Finally, and related to the task impurity outlined above, WCST offers low construct validity (Miyake et al., 2000). Notwithstanding its wide usage, the complexity of the measure and its reliance on other cognitive competencies reduced its efficacy to assess cognitive flexibility in the main fieldwork.

Dimension Change Card Sort

The Dimension Change Card Sort (DCCS) was used during both pilots and the main data collection. In each case, it was administered using the Zelazo (2006) protocol and pre-programmed tablets to record the pupils' responses. Reaction times, specifically the number of seconds to place all 12 cards, were also captured in the fourth round of the task using stopwatches.

During the initial pilot, the first round served as a useful warm-up activity and most pupils from each class were able to complete the post-switch trial successfully. A small number of Primary 1 children perseverated and played largely or exclusively the colour or shape game throughout the task, demonstrating minimal cognitive flexibility. Figure 1A.1 shows the distribution of correct sorts by class across the third and fourth trials, while Figure 1A.2 plots accuracy scores on the third and fourth trials against one another. The positive, if fairly loose, correlation suggests some consistency and reliability between the task items. Further, *t*-tests performed in Stata revealed that with one exception (pupils assessed by one enumerator in the first pilot scored significantly lower on the third DCCS trial), there were no significant differences between pilot pupil scores depending on gender, whether the assessment was conducted in the afternoon or morning, the identity of the enumerator, or whether the test was co-enumerated (Cohen et al., 2015).

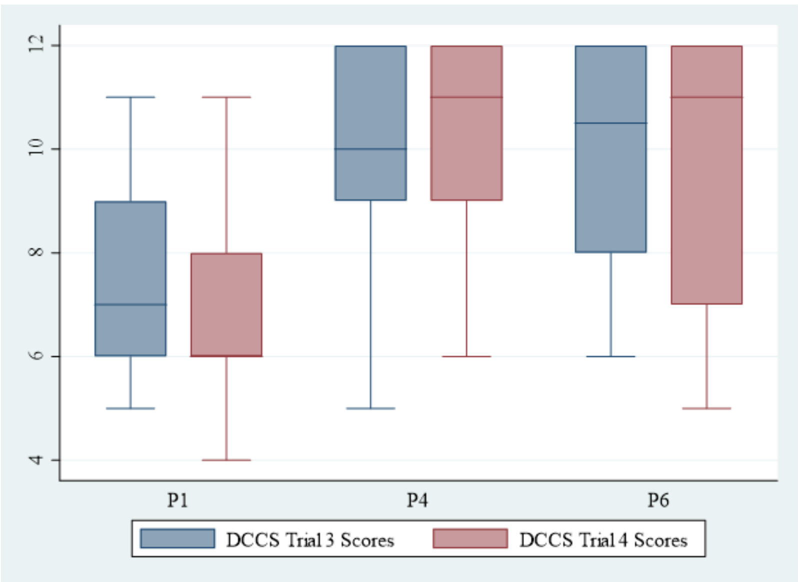


Figure 1A.1 – DCCS Distribution of Scores by Class
Source: Primary data, 2017.

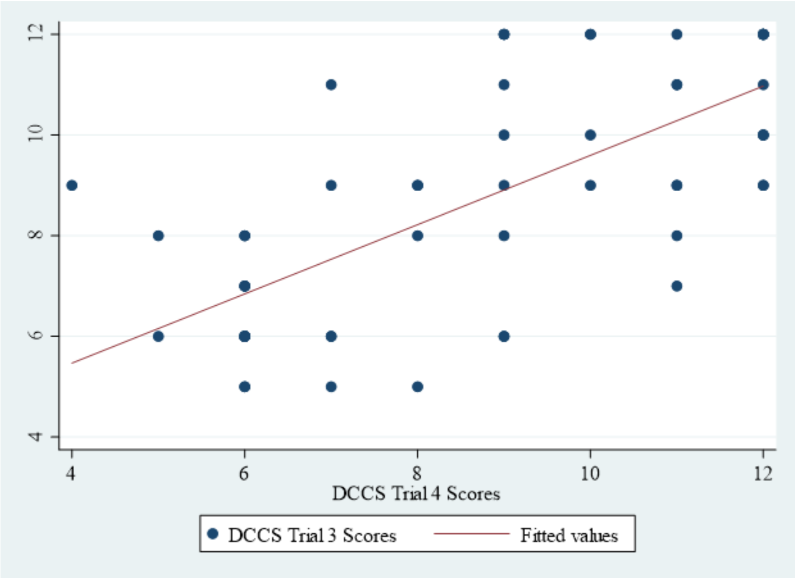


Figure 1A.2 – Accuracy Scores on Third and Fourth DCCS Trials
Source: Primary data, 2017.

At Primary 4 and 6 levels, the accuracy scores showed ceiling effects with many children achieving all 12 correct sorts. For this reason, and to provide greater nuance, the reaction times were used to generate composite indicators for the fourth trial using the following calculations (Pritchard & Woodward, 2011):

$$\text{Performance score} = \text{Number of incorrect sorts x Reaction time (in seconds)}$$

$$\text{Efficiency score} = \frac{\text{Number of correct sorts} - \text{Number of incorrect sorts}}{\text{Reaction time (in seconds)}}$$

The performance and efficiency scores are plotted against the age of pilot pupils in months in Figures 1A.3 and 1A.4 below. In each case, the results appear as would be expected: performance scores reduce with age as the pupils made fewer incorrect sorts and in less time; and efficiency scores increase as correct sorts exceeded incorrect sorts, again requiring less time.

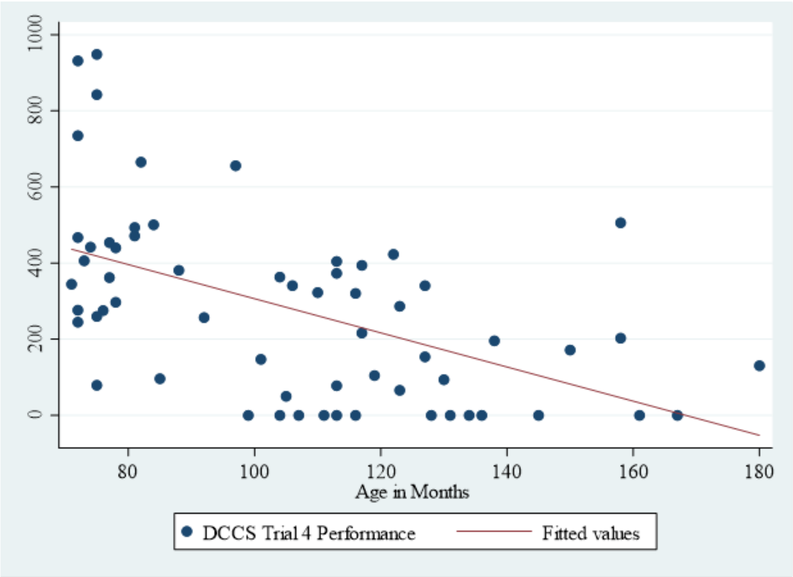


Figure 1A.3 – DCCS Fourth Trial Performance Scores against Ages in Months
Source: Primary data, 2017.

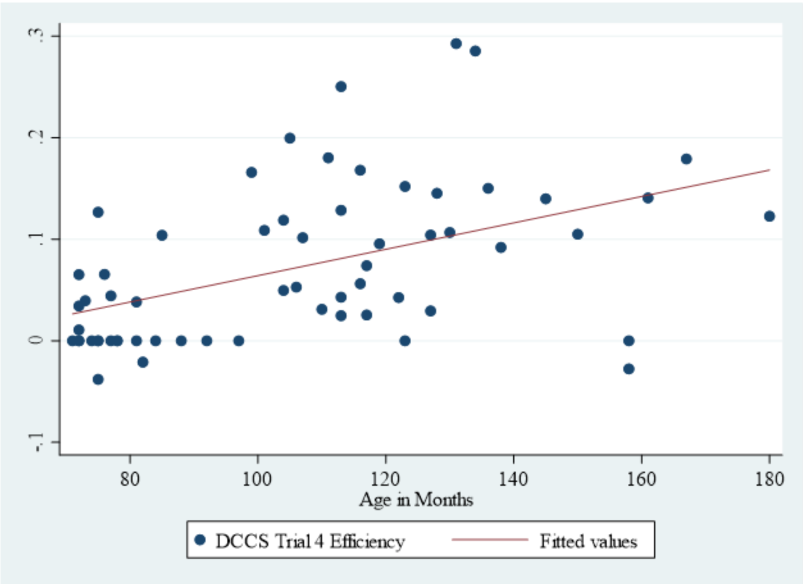


Figure 1A.4 – DCCS Fourth Trial Efficiency Scores against Ages in Months
Source: Primary data, 2017.

Following the successful use of the DCCS in the first pilot, the measure was used again in the second pilot and then during the main fieldwork. Basic analyses after the second pilot revealed that the DCCS continued to offer variation among Primary 1 and 4 pupils in a *public* school and so was deemed appropriate for use in the four case study schools. In terms of data collection, the only adjustment required from the first pilot was that the word 'border' was difficult to translate into Kinyarwanda for the children, and so the word 'box' was used instead.

Flexible Item Selection Task

In addition to the DCCS, the Flexible Item Selection Task (FIST) was used as a further measure of cognitive flexibility in the second pilot and main fieldwork. Data from the pilot showed that the FIST also offered suitable variation between the Primary 1 and 4 pupils. However, enumerating six trials over five rounds proved very time-consuming and made the assessments too long, over an hour for the slower children. This raised ethical issues of taking the pupils out of class for extended periods and the children themselves seemed to lose patience and enthusiasm for the task after the first couple of rounds.

Consequently, I reduced the number of FIST rounds in the main fieldwork and introduced 'stop' rules to control and determine pupils' progression. Specifically, the children needed to pass the demonstration and criterial trials to attempt the 2-match round, and then achieve a minimum level of performance to progress onto the 4-match round. This approach brought the total assessment time to a more acceptable duration while still ensuring variation across learners' responses.

Object-based Pattern Reasoning Assessment

Beyond measures for cognitive flexibility, both pilots and the main fieldwork included the Object-based Pattern Reasoning Assessment (OPRA) to gauge learners' non-verbal reasoning. Figure 1A.5 below shows the distribution of scores by class in the first pilot, while Figure 1A.6 plots scores against age in months. As with the DCCS, there were no differences in scores by gender, enumerator or time of assessment.

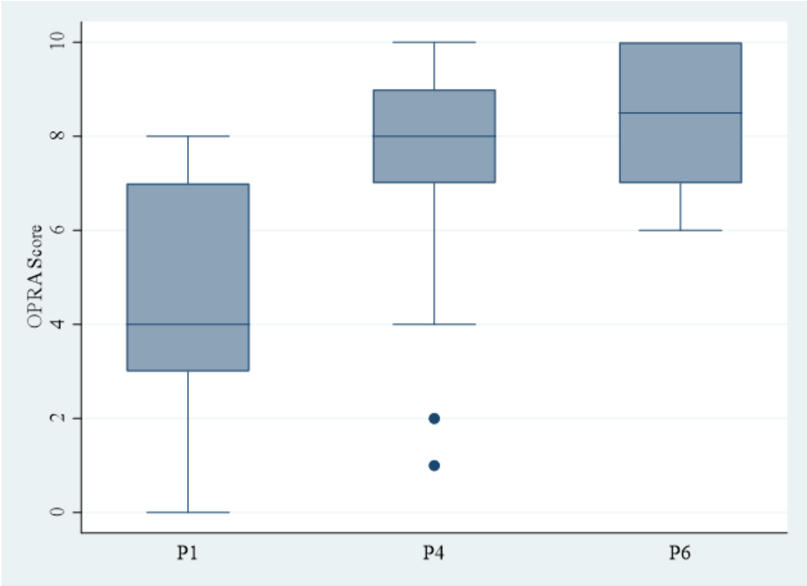


Figure 1A.5 – Distribution of OPRA Scores by Class
Source: Primary data, 2017.

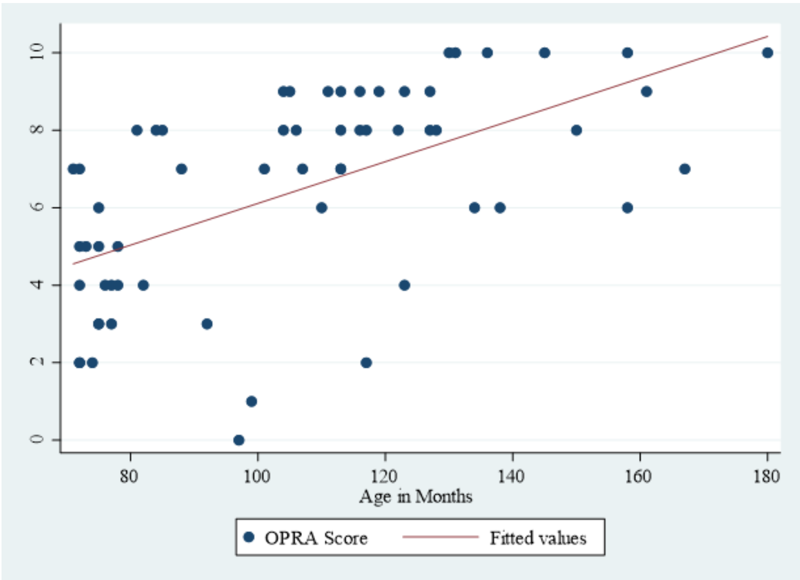


Figure 1A.6 – OPRA Scores against Age in Months
Source: Primary data, 2017.

Although there were some ceiling effects among the Primary 6 pupils in the first pilot, the test appeared suitable for wider use and was included in the main fieldwork. Administration instructions and practices remained the same throughout, save that after the first pilot the grids were presented vertically to avoid any left-to-right bias, or any perception that a pattern could continue over from one grid to the next.

Tower of Hanoi

Throughout the pilots and the main fieldwork, each pupil's global executive function was assessed using the Tower of Hanoi. Protocols for administering the task vary as to whether they start with the simple trials and get harder, or with the difficult rounds and get easier (Borys et al., 1982; Bull et al., 2004). The first pilot in Rwanda therefore sought to combine these approaches by starting with timed three- and four-disk rounds before working through a series of increasingly challenging three-disk exercises.

The results from the first pilot were somewhat mixed. Within each class, there were pupils who mastered the activity and completed the task within the allotted time. However, there were also pupils at every level who struggled to achieve even the more basic exercises. Particularly among the Primary 1 children, there were very few who were able to complete the three-disk task. In light of such data, I reorganised the Tower of Hanoi administration for the second pilot, which provided better variation during the second pilot and so was used in the main data collection.

Reaction Times

Throughout the pilots and the core fieldwork, enumerators used stopwatches to record pupils' reaction times during the fourth round of the DCCS. Such an approach was taken to try to increase the granularity of data concerning learners' cognitive flexibility. As described above, the data from the first pilot yielded interesting insights regarding the relationship between respondents' age, performance and efficiency as shown in Figures 1A.3 and 1A.4. However, as noted above, many pupils in the main fieldwork were unable to perform the more basic matches and therefore did not progress to the third and fourth rounds of the task. This gave rise to a large number of missing time values for the lower-performing children.

Numerous studies of cognitive flexibility using the DCCS have similarly captured data on respondents' reaction times (Chevalier & Blaye, 2009; Dauvier et al., 2012; Zelazo et al., 2013). In each case, participants from high-income contexts have *themselves* used tablets or computers to enter their selections, thereby recording response speeds for individual matches. By contrast, in the current study, the enumerators entered pupils' choices for them and captured the total time taken to place all twelve cards. This approach was taken to minimise any differences in performance that could result from children’s unfamiliarity with electronic devices or two-dimensional stimuli (Zuilkowski et al., 2016).

In light of these constraints, pupils’ reaction times were excluded from the final DCCS analyses. Despite the potential value of these data, the response speeds appeared too unreliable and inconsistent to offer any valid or meaningful insights. Further, they risked confounding executive function with motor skills, with any delays attributable to slow reactions by the child, the enumerator or possibly even both (Bishop et al., 2001).

Appendix 2 – Rwandan Approvals

REPUBLIC OF RWANDA

Kigali, 19/12/2017
N°. 2874..../12.00/2017

MINISTRY OF EDUCATION
P.O.BOX 622 KIGALI

Re: Permission to Carry out Research in Rwanda - No: MINEDUC/S&T/472/2017

The Permission is hereby granted to **Mr. Stephen Hamilton Bayley,** PhD Student, Faculty of Education, University of Cambridge, UK and **Ms. Umutoniwase Sonia,** Research Assistant and Translator to carry out research on: **"Cultivating Cognitive Competencies in Resource-Constrained Environments: A Multi-School Case Study in Rwanda".**

The research will be carried out in selected five schools located in Gasabo and Nyarugenge Districts, Kigali City. The researchers will need access to National Examination records for public school performance in Gasabo and Nyarugenge District. Researchers will need to interview officials from the Ministry of Education, Rwanda Education Board and University of Rwanda-College of Education. They will need also to interview school head teachers as well as teachers. Pupils' assessment will be conducted to selected students from the selected schools.

The period of research is from **01st January, 2018 to 30th July, 2018**. It may be renewed if necessary, in which case a new permission will be sought by the researchers.

Please allow the **above mentioned researchers**, any help and support they might require to conduct this research.

Yours sincerely,

[redacted] 19/12/2017

Marie-Christine GASINGIRWA, Ph.D
Director General of Science, Technology and Research

REPUBLIC OF RWANDA

Kigali, 19/12/2017
Nº 2875/12.00/2017

MINISTRY OF EDUCATION
P.O.BOX 622 KIGALI

Mr. Stephen Hamilton Bayley
PhD Student
Faculty of Education
University of Cambridge
Email: [redacted]
UK

Dear Mr. Stephen Bayley,

RE: Approval to Conduct Research in Rwanda under the Project Title: "Cultivating Cognitive Competencies in Resource-Constrained Environments: A Multi-School Case Study in Rwanda"

I am pleased to attach a copy of research clearance, which has been granted to you to conduct research on the above title.

I wish to remind you that the research clearance number should be cited in your final research report. The research will be carried out under affiliation of the University of Rwanda-UR under supervision of **Assoc. Prof. Evode Mukama,** College of Education, University of Rwanda.

You are requested to submit the final report after completion of your research activities to the Ministry of Education of Rwanda.

I wish you success in your research.

Yours sincerely,

[redacted]

Marie-Christine GASINGIRWA, Ph.D
Director General of Science, Technology and Research

Cc.

- Hon. Minister of Education
- Hon. Minister of State in Charge of TVET
- Hon. Minister of State in Charge of Primary and Secondary Education
- Permanent Secretary, Ministry of Education
- Assoc. Prof. Evode Mukama, College of Education, University of Rwanda

REPUBLIC OF RWANDA

Gasabo,..02../..02...../2018
Ref.No :..222../.07.01.02/2018

KIGALI CITY
GASABO DISTRICT
WEBSITE : www.gasabo.rw
E-mail : [redacted]
B.P. 7066 KIGALI

STEPHEN Bayley
Tel.: 0788473108
KIGALI

Dear Mr. Stephen Bayley,

RE: Your permission to conduct educational research in Gasabo District

Reference is made to your letter dated 24th January, 2018 requesting permission to conduct research in Gasabo District, Public Primary Schools which are: Ecole Primaire Gatsata II, GS Kacyiru II, Ecole Primaire Kibagabaga, GS Gisozi I, Ecole Primaire Gisozi II, Ecole Primaire Kacyiru I;

Reference is also made to the letter of Ministry of Education Nº 2875/12.00/2017, which granted you permission to carry out research on "Cultivating Cognitive Competencies in Resource Constrained Environment: A Multi-School Case Study in Rwanda";

It is in that regard that you are permitted to conduct research in Gasabo District Public Primary Schools.

Sincerely,

[redacted]

RWAMULANGWA Stephen
Mayor, Gasabo District

Website : www.gasabo.gov.rw. E-mail : [redacted] *P.O Box 7066 Kigali*

REPUBLIC OF RWANDA

Kigali, ..18../..1../2018
Réf n°....216.../01.01/08

KIGALI CITY
NYARUGENGE DISTRICT

TO: Stephen Bayley
Tel : 0788473108

<u>RE: Permission to conduct Education Reseach in Nyarugenge District</u>

This comes to inform you that you have been accepted to conduct your Education reseach in Nyarugenge District as requested in your application letter. You will be working in Nyarugenge District about « **Cultivating cognitive competencies in resource-constrained emvironments** »

You will be expected to have Maximum co-operation with the school head teachers as requested to.
We hope that out partmership will benefit you and our organization.

Your sincerely.

[redacted]

HATEGEKIMA FRED
Executive secretary of Nyarugenge District

B.p 1092Kigali *E mail :* [redacted] *website :www.nyarugenge.gov.rw*

Appendix 3 – Case Study School Descriptions

This appendix describes the four case study schools selected for participation in the present research.

School 1 was situated on a hillside in a densely populated area of urban Kigali in Nyarugenge district. The school was surrounded by a large number of visibly unplanned settlements, comprising single storey houses built with grey ash blocks and roofs of patchwork corrugated iron. Despite the urban location, School 1 benefited from a spacious campus, including a large sports pitch, a fully equipped computer room and a well-stocked book store. Like the other schools, the infrastructure looked aged and was poorly maintained. Unlike the other schools, School 1 was established as a *groupe scolaire* and accommodated over 1,000 pupils from primary through to upper secondary. The children's appearance was quite mixed, some wearing closed shoes while others played in tatty flip-flops. Nevertheless, the school ranked in the top half of schools shortlisted in the district.

School 2 was located under a kilometre away, also in Nyarugenge but at a different elevation on the ubiquitous Kigali hillside. The adjoining area featured a greater number of commercial properties and outlets than School 1, not least due to proximity to a fairly major road. Again, the campus was large and spacious, with a designated computer room and an impressive collection of books, although the large play area was unpaved and became a field of mud during the seasonal rains. School 2 included several nursery classrooms and continued to Primary 6, with over 2,000 learners across the different grade cohorts. The children seemed to dress more smartly than pupils in School 1, but the school came towards the bottom of the shortlist ranking based on 2016 national examination performance.

In the second district, Gasabo, School 3 was situated along a dirt road and more remotely positioned than the other schools. A nearby open market and agricultural land created a sense of greater space but the school lay wedged between one neighbourhood of closely packed basic housing and another of some affluence. The buildings were in reasonable condition but the site was fairly cramped, not least given its hillside location. The school infrastructure was limited to classrooms, pit latrines and a small administration block comprising the staff room and two small offices. There was no designated computer room or library, rather learning materials were stored in the staff room. The playground area was also small, unpaved and on a steep slope. The school accommodated over 1,000 learners in primary classes only, but despite their unkempt appearance, pupils' performance on national assessments ranked the school in the top half of the sampling shortlist for the district.

Finally, School 4 was located several kilometres away, also in Gasabo but too far for any likely overlap in catchment areas with School 3. The immediate area appeared more affluent than the other schools, with nearby unplanned settlements less visible and situated a short walk away. The campus was spacious, landscaped and generally tidier and better kept than the other schools. The large playground was paved and the school contained a well-stocked storage room of learning materials. School 4 offered primary classes only to over 2,000 pupils and the school ranked towards the bottom of the shortlist of schools in terms of 2016 examination performance in that district.

Appendix 4 – School Interview Schedule

Introduction

1. How much time do you have available?
2. Would you be happy for me to record this interview?
3. Please explain your role at the school and what it involves.
   (Prompts: subjects, primary classes and number of cohorts taught)
4. How long have you been working at this school for?
5. How long have you been working as a teacher/head teacher for in total?

Teacher Trainings

6. Please describe the trainings you've participated in over the past year.
   (Prompts: where did the training take place, who conducted it, how long did it last, what were the main focuses)
7. FOR TEACHERS ONLY: Please tell me about any observations of your lessons over the past year.
   (Clarification: observation of full lesson including feedback for the purposes of improving instruction, NOT for research purposes)
   (Prompts: who conducted the observation, how frequently, nature and content of the feedback)

Curriculum and Cognitive Competencies

8. Rwanda introduced a new competence-based curriculum in February 2016. The curriculum talks about the value of flexible and adaptable learners with competencies such as creativity, innovation and problem solving – *guhanga udushya*, *ubudasa* and *kwishakira ibisubizo*. What do you understand by these terms?
9. Why do you think such competencies are included in the curriculum?
10. Do you feel such competencies may have different importance among different groups or different contexts, for example, men and women, rural and urban? If so, why?
11. In what ways do you foster these competencies among pupils inside the classroom?

(Prompt: this could be through particular pedagogical practices or activities, or the use of learning aids)

12. In what ways do you foster these competencies among pupils *outside* the classroom? *(Prompt: this could be through involvement in clubs, groups, extra-curricular activities etc.)*
13. How do your colleagues support you to foster these competencies among your pupils? *(Prompt: this could be through formal or informal mentoring, trainings and/or observations)*
14. Are there any ways in which you support your colleagues to foster these competencies, and if so how?

    (Prompt: this could be through formal or informal mentoring, trainings and/or observations)
15. In what ways do you think that the school is supporting the development of these competencies among its pupils?
16. In what ways do you think that the competence-based curriculum is supporting the development of these competencies among learners in your school?
17. What changes would you like to see in order to improve your support for these competencies among your learners?
18. How do you assess these competencies in your learners?
19. What are your views on the assessment of these competencies?

Closing

20. Why is your pupils' learning important to you?
21. Do you have any other views on the issues that we've discussed that you would like to share?
22. Finally, would you like to receive an electronic transcript of our conversation? (If so, please provide your email address.)

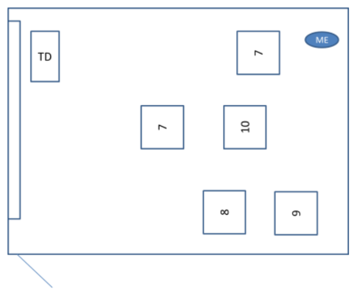
Thank you for your time and input.

Appendix 5 – Example Completed Observation Schedule

Date of Observation	2/5/2018						
Name of School	XX						
School Code	Y						
Name of Teacher/Instructor	MM			**Gender**	Male	X	Female
Teacher/Instructor Type (please circle)	Subject	Class	Supply/ Substitute	School-Based Mentor		Other (specify)	
Class/Grade(s)	P4E						
Class Subject	Social Studies						
Class Topic(s)	Civic Education – Flags						
Observation Start Time	15.10						
Observation End Time	16.27						
Name of Observer	Stephen						
Number of Pupils at Start	41						
Number of Pupils at End	40						
Number/Description of Adults (exc. Observer)	1 teacher						

1. Classroom Set-Up

Sketch layout of classroom including: black/white board, teacher desk, pupil/student desks and configuration, door(s), window(s)



Tick as appropriate

	Yes	Some	No(ne)
Dustbin			?
Clean floors		X	
Desks and chairs in reasonable condition	X		
Children wearing uniforms	X		
Teaching and learning materials displayed on walls			X
Children's work displayed in classrooms			X

Pupil seating (please circle)	Floor	Chairs/ benches only	Chairs/ benches around tables	Chairs/ benches in rows

2. Lesson Description

Provide detailed narrative description of *teacher* activities, practices, behaviours and language over nine-minute periods. Summarise the activities of *pupils/students* in the preceding nine minutes during the tenth minute.

Time	Narrative Description
15.12	The teacher asks pupils for the class rules. Individual pupils respond 'No shouting in class', 'no fighting in class' and 'listen to the teacher'. The teacher clarifies that they must listen to him then he writes 'Social Studies' on the board. He asks pupils the name of their country and a pupil answers 'Rwanda'. The whole class repeats 'Rwanda' and the teacher asks for the names of other countries. The pupils respond 'Uganda', 'Burundi', 'Tanzania' and the teacher asks for special signs to represent one's country. A pupil responds in Kinyarwanda and the teacher emphasises 'special sign' and speaks in Kinyarwanda. Another pupil answers 'coat of arms', and another 'flag'. The teacher then holds up a sheet from the board with flags on it and asks 'have you seen?' He reveals a sheet on the board with seven flags and tells the pupils to discuss them in their groups. He speaks in Kinyarwanda before asking what they've seen. Group 1 stand and the teacher tells one pupil to present. A pupil answers 'map of Rwanda' and the teacher tells them to sit down. He then gets Group 2 to stand and speaks to them in Kinyarwanda. A pupil says 'Tanzania' and another pupil (from Group 1) says something in Kinyarwanda about 'colour'. The teacher says that someone should respond in English and another pupil says 'flags'. A further pupil says that they see seven flags and the teacher asks how many countries are represented if they see seven flags. The pupil answers seven and they all count the flags together. The teacher then holds up the first sheet and says that there are nine in total, therefore nine countries.
15.21	The pupils sit quietly looking at the teacher, sitting still. They discuss in groups as invited and a girl goes forward to point at the flag.
15.22	The teacher asks the girl to show the Rwandan flag. The pupils say her selection is not right and another pupil comes up to correct her. They speak in Kinyarwanda and the teacher asks what they can see. A pupil responds 'Izuba' (sun) and the teacher says to speak in English. He asks what they can see then talks through the colours, green, yellow, blue and the sun in the blue colour. He explains that if they can see flags they know which flag represents their country. The teacher then writes up 'Civic Education' on the board and gets the pupils to repeat it. Next, he writes 'Unit 5: Civics and Governance' and explains that civics covers history, economics etc. of one's country. He speaks in Kinyarwanda then asks where 'Governance' comes from, which verb, and then answers 'to govern'. He writes 'FLAG' and explains that Rwanda has a flag that represents the country. He speaks in Kinyarwanda again and asks a question. A pupil replies 'coat of arms' and the teacher reveals a sheet with the coat of arms and talks through the different components (coffee, peace basket etc.). He repeats 'ubumwe' (unity) and patriotism. The teacher then asks for a third special sign for the country. A pupil answers 'national symbol' and the teachers asks for someone to help. A Group 2 pupil gives an answer and the teacher says to try to respond in English. A pupil then stands and says 'national anthem'.

15.31	The pupils sit and look, occasionally chattering, but otherwise still. They put their hands up and answer when they're asked.
15.32	The teacher asks for three signs and the pupil who first answered 'coat of arms' answers 'flag, coat of arms…' and the teacher asks the next table for the last answer. Another pupil responds 'National anthem'. The teacher speaks in Kinyarwanda then writes '1. Flag 2. Coat of arms 3. National anthem' on the board. He then sticks the Rwandan flag on the board and asks how many colours it has. A pupil stands to answer '3'. The pupils answer 'blue, yellow, green' and the teacher asks 'What do you see about this colour? Why has Rwanda chosen these colours?' A pupil responds regarding blue that 'it is a good colour' and the teacher asks 'what else?' The coat of arms boy answers that because in the weather there is the blue colour and another pupil answers in Kinyarwanda. The teacher responds that it should show the difference with the country. Another pupil answers in Kinyarwanda and the teacher says to clap for her. He explains that the colours of Rwanda have significance and meaning, speaks in Kinyarwanda and the pupils put their thumbs up. The teacher then speaks to an older girl at the back quietly in Kinyarwanda. Back at the front, he addresses the class in Kinyarwanda and says that they have to understand the country and to understand how to govern the country. He speaks in Kinyarwanda again and points at the list of national symbols.
15.41	There is some fidgeting but most of the pupils appear to be watching the teacher. A couple rest their heads looking sleepy, but there is little chattering.
15.42	The teacher explains that the new flag was adopted on 25th October 2001, and that the blue colour has significance. He then speaks to the older girl, gesturing about putting water on her head and she gets her bag and walks out. The teacher gets a pupil to stand and read the meaning of blue from the sheet (relates to peace and harmony). He gets another pupil to read it again, then speaks in Kinyarwanda and the pupils put their thumbs up. The teacher asks if the peace and harmony is for animals or humans, and then responds for all of them. He speaks in Kinyarwanda then gets a pupil to stand at the front. A couple of pupils don't answer then a girl does. The teacher asks her to say it in English, please, and the pupil answers in English and gets a clap. The teacher then reads the meaning of blue and gets the pupils to recite it after him. They do the same for yellow – the teacher asks them to explain, a pupil does, the teacher says to try to explain in Kinyarwanda, a pupil answers and receives 'flowers'. The teacher speaks in Kinyarwanda again and a few pupils try to explain blue in Kinyarwanda. They remain with one colour, and a pupil answers 'green'. The teacher explains that green stands for the richness and natural resources. He asks someone to explain in English and explains in Kinyarwanda.
15.51	There's some fidgeting and the older girl goes out. There's some chattering at the back left but lots of hands going up.
15.52	The teacher talks about the sun on the flag and asks how many rays there are. A boy answers '24' and receives 'flowers'. The teacher explains that the sun stands for unity and asks for the word in Kinyarwanda. A pupil answers 'ubumwe' and the teacher explains that the new flag was adopted after the war. He speaks in Kinyarwanda and explains that the sun represents unity, openness and – speaking again in Kinyarwanda – he says that during the day we receive what? A pupil responds 'light' and the teacher says it also refers to understanding. He then says to sit in groups to find questions and get paper. He gets them to sit in five groups and to look at the board. He then points at three questions '1. What are the special signs? 2. Match the colours with their meaning'…then he speaks in Kinyarwanda. He starts to read '3. What is…' but then interrupts to tell a pupil he's shouting. He gets a pupil to read the last

	question 'What is the importance of Rwanda?' The teacher clarifies that of the national flag then moves around the tables saying 'Discuss', speaking to the pupils in Kinyarwanda and asking where the groups are.
16.05	The pupils work in small groups. There is low chatter, some stand and lean over the tables, some sit.
16.06	The teacher gives the pupils a few more minutes. He asks if they're ready and they say 'no'. He encourages them to go 'quickly – going to stop you' then uses masking tape to stick various things on a table. The teacher says he will count to 10. Pupils ask for 15 or 20, but the teacher says 'no' and starts counting 1 to 10, moving around and clapping with each count. He claps 10 and says 'stop there'. He tasks representatives from the groups to choose and present with their paper and the representatives get up from each table. The teacher tells them 'quickly' and he arranges them in front of the board. He then says to pay attention, to listen to the reps and asks the first, what is the answer, speaking in Kinyarwanda. The first two pupils are fairly inaudible but say 'Rwanda' and 'coat of arms' and the teacher says to clap for this group.
16.13	The representatives stand at the board and answer questions. The other pupils chatter more, with some fidgeting. Some other pupils raise their hands.
16.14	The teacher asks for the colours' meaning. A pupil reads 'peace and happiness in the country' then another reads the same thing regarding the blue meaning. The teacher asks a pupil to read the meaning of the sun, then reads different meanings of the sun and asks if it's correct. He draws a line on the chart to link the colours with their meanings. He then asks the importance of the national flag according to you? The coat of arms boy answers and the teacher says 'very good'. The teacher then writes new answers on the sheet, mixing English with Kinyarwanda. He speaks in Kinyarwanda and hands go up, pupils answering various questions in Kinyarwanda. Then the teacher asks what their contribution will be and says to answer in English. One pupil answers 'Not troubling friends'. The teacher asks about yellow and a boy gives a long answer in Kinyarwanda, the coat of arms boy answering too. The teacher then thanks the class and tells them that they need to write the notes in their notebooks. He says that tomorrow's class will be on the coat of arms.
16.26	Much more fidgeting and shuffling.

TO BE COMPLETED *AFTER* THE LESSON OBSERVATION IS COMPLETE

3. Teaching Style, Lesson Language and Use of Learning Aids

Style	**All the time**	**Frequently**	**Occasionally**	**Rarely**	**Never**
Lecturing		**X**			
Whole-class teaching		**X**			
Q&A					**X**
Small group work		**X**			
Individual work					**X**

Comments/Description

……………………………………………………………………………………………

Teacher Language(s) Used	**Exclusively**	**Mainly**	**Partial**	**Few words**	**Not at all**
Kinyarwanda			**X**		
English		**X**			
French					
Other (please specify)					

Other language(s) used and frequency

…………………………………………………………………………………………

Learning Aid	**All the time**	**Frequently**	**Occasionally**	**Rarely**	**Never**	**How aid used**
Black/white board		**X**				
Wall charts		**X**				Used a lot by the teacher
Textbooks					**X**	
Computer					**X**	
Tablet					**X**	
Other (describe below)					**X**	

Other learning aid(s) used and frequency of use

…………………………………………………………………………………………

4. Evidence of Specific Behaviours

Describe examples/evidence of:

Behaviour/practice	
Looking at something from more than one perspective	Discussing significance of colours in Rwandan flag – represent different things Alluding to peace and harmony for animals as well
Applying learning to a real-life problem or responding creatively to life challenges	None
Switching tasks or rules within the same task	Some in class
Using imagination to generate new ideas to enrich learning	None
Taking initiative to explore challenges or generate original ideas	None
Code switching between languages	Frequently
Use of or reference to formative assessment or feedback (to groups or individuals)	None

General Comments (e.g. teacher demeanour, observation reactivity)
The teacher didn't seem to look over much. He seemed very well prepared with the learning charts. I wonder if this is normally the case? The pupils seemed unfazed by me.

Appendix 6 – Pupil Assessment and Questionnaire

DATE: ……………………………………………………………………

ENUMERATOR: …………………………………………………………………….

SCHOOL NAME/CODE: ……………………………………………………………………

DISTRICT: …………………………………………………………………..

CO-ENUMERATED? Yes…………………..No…………………(circle answer)

GPS LOCATION: ……………………………………………………………………

BEFORE STARTING:

- [*All instructions to the enumerator are in italics*]
- [*All instructions and questions to be read to the pupil are <u>underlined</u>*]
- [*Your role is to conduct the games/tests described below and collect the answers to the questions at the end. You should also make the pupil feel at ease and not afraid of answering the questions. They should feel reassured that they are not in trouble and they won't be in trouble if they don't know the answers to the questions or don't wish to participate in one or more of the games.*]
- [*Ensure that the cards and games are set up properly in advance – in particular that the D1 Dimension Change Card Sort cards are in order, and that the D2 Object-based Pattern Reasoning Assessment is already set up with the spaces in the correct places*]
- [*For the timed rounds, it is important that you give the pupil a clear signal to start and commence timing immediately, and finish as soon as they complete the task*]
- [*Check that the pupil is comfortable and which language he/she would like to use]*
- [*Ask whether he/she needs to use the toilet before starting*]
- [*When you and the pupil are ready, read the following briefing:*]

<u>My name is</u> [*say your name. Also introduce any other persons present*].

<u>We would like to play a few games with you today and to ask you some questions. We've spoken to your Head Teacher and he/she says that he/she is happy for us to play the games with you and your classmates. The games generally involve you sorting cards using different shapes and colours, and solving problems with basic toys. We would also like to see how your reading skills are progressing and to ask you a few questions about your home life and earlier schooling. Are you happy to take part?</u>

[*Assuming the pupil consents (if not, escort him/her back to class)*]

<u>Great. If you change your mind for any reason, or decide that you don't want to play the games any longer, that's no problem – just say so. I won't be upset, no one will be upset with you. You also don't have to answer any questions you don't want to, and no one at the school nor at home will find out how you've answered the questions.</u>

<u>Are you ready to start?</u>

PUPIL NAME: ……………………………………………………………

PUPIL CODE: ………………………………………………………………

PUPIL CLASS: ………………………………………………………………

PUPIL GENDER: Male …………………Female………………(circle answer)

AGE: ………………………………………………………………

DATE OF BIRTH: ………………………………………………………………

LANGUAGE USED: Kinyarwanda Kirundi Kiswahili

English Other (specify) (circle answer(s))

START TIME: ……………………………………………………………

END TIME: ……………………………………………………………….

D1. DIMENSION CHANGE CARD SORT

Guidelines

[*For this game, sit to the side of the pupil (but do not let him/her see your record sheet/tablet!). Except for the target cards, all cards should be placed FACE DOWN in this game.*

During the game, allow pupils to change their responses, if they want, up until they turn over the next card or you repeat a rule. If they do ask to change, simply say "<u>Are you sure?</u>*" but do not provide evaluative feedback before proceeding to the next trial.*

Pupils must not pick up or look at previously sorted cards. Tell them, "<u>You've already sorted those cards, but let's do another one.</u>*"*

When the pupil has completed the exercise, place the target card on top of each pile and, keeping them in their piles, move them out of the pupil's reach.

Do not pick up or review the sorted cards until AFTER the pupil has left the room. Only then should you review the sorted cards and circle in the list those that have been incorrectly sorted.]

Introduction

<u>The first game involves playing with shapes and colours. Do you like shapes and colours?</u>

[*Sit beside the pupil and turn over the first two target cards. Place the green goat (marked DT1) and the yellow moto (marked DT2) face up in front of the pupil*]

<u>Here's a green goat and here's a yellow moto.</u>

1. Demonstration Phase

<u>This is the colour game. In the colour game, all the green ones go here</u> [*pointing to a space below the green goat target card*]<u>, and all the yellow ones go there</u> [*pointing to a space below the yellow moto*

card]. See, here's a green one [*a green moto*]. So it goes here [*place it face DOWN below the green goat target card*].

Remember, if it's green it goes here, but if it's yellow it goes there.

Now here's a yellow one. [*Show the pupil the next card (i.e. a yellow goat)*]

Where does this one go? [*Hand the card to the pupil*]

[*If the pupil takes the card and sorts it correctly (i.e. below the yellow moto), or simply indicates the correct target card by pointing, say*]

Very good. You know how to play the colour game.

[*If the pupil points only, say*]

Can you put this yellow one down?

[*Ensure that the card is placed FACE DOWN in the appropriate place, turning the card over if necessary*]

[*If the pupil sorts incorrectly (i.e. below the green goat target card), say*]

No, this one's yellow, so it has to go over here in the colour game. Can you put this yellow one down?

[*Ensure that the card is placed face-down in the appropriate place*]

2. Pre-Switch Trials

Now it's your turn. So remember, if it's green it goes here, but if it's yellow it goes there.

[*Turn over the next card, show it to the pupil and label it by the COLOUR ONLY*]

Here's a yellow/green one [*Hand it to the pupil*] Where does it go?

[*Ensure that the pupil places the card on top of the preceding cards, face down. Whether or not the pupil sorts correctly, simply say*]

Thank you, let's do another one. Here's a yellow/green one. Where does it go?

[*Continue until the pupil reaches the black break card. Record below where the pupil places each card. DO NOT inform the pupil whether the choice is correct or not*]

Card	Target Card – Green Goat	Target Card – Yellow Moto
3		
4		
5		
6		
7		
8		

[*Before proceeding, count whether the pupil has achieved at least four correct sorts. Correct answers are shown by the shaded cells. If he/she has, proceed to the next trial. If he/she has not achieved at least four correct sorts, move to the next activity (D2 – Object-Based Pattern Reasoning Assessment).*]

3. Post-Switch Trials

Now we're going to play a new game. We're not going to play the colour game anymore. We're going to play the shape game. In the shape game, all the goats go here [*pointing to the space below the green goat target card*], and all the motos go there [*pointing to the space below the yellow moto target card*]. Remember, if it's a goat, put it here, but if it's a moto put it there. Okay?

[*Do not remove the target cards or any of the cards that were sorted during the pre-switch phase, and do not pause between pre- and post-switch phases. Turn over the next card and show it to the pupil*]

Here's a goat/moto. [*Hand the card to the pupil*] Where does this one go?

[*Ensure that the pupil places the card on top of the preceding cards, face down. Whether or not the pupil sorts correctly, simply say*]

How about another one? Here's a goat/moto. [*Hand the card to the pupil*] Where does this one go?

[*Continue until the pupil reaches the black break card. Record below where the pupil places each card. DO NOT inform the pupil whether the choice is correct or not*]

Card	Target Card – Green Goat	Target Card – Yellow Moto
10		
11		
12		
13		
14		
15		

[*Before proceeding, count whether the pupil has achieved at least four correct sorts. Correct answers are shown by the shaded cells. If he/she has, proceed to the next trial. If he/she has not achieved at least four correct sorts, move to the next activity (D2 – Object-Based Pattern Reasoning Assessment)*]

4. Box Trials

Okay, you played really well. Now I have a more difficult game for you to play. In this game, you sometimes get cards that have a black box around it like this one

[*Hold up and show the pupil a card showing a yellow goat within a box*]

If you see cards with a black box, you have to play the colour game. In the colour game, yellow ones go here and green ones go there [*pointing to the appropriate places*]

This card's yellow, so I'm going to put it right there

[*Place it face down below the yellow moto target card*]

But if the cards have no black box, like this one

[*Hold up and show the pupil a card showing a yellow goat without a box*]

You have to play the shape game. In the shape game, if it's a goat, we put it here, but if it's a moto, we put it there [*pointing to the appropriate places*]

This one's a goat, so I'm going to put it right here

[*Place it face down in the appropriate place*]

Okay? Now it's your turn

[*As the pupil turns over the first card, repeat*]

Remember, if there's a box, play the colour game. If there's no box, play the shape game.

This card has a box/does not have a box. Where does it go?

[*Ensure that the pupil places the card on top of the preceding cards, face down. Whether or not the pupil sorts correctly, simply say*]

Thank you. Let's do another one.

This card has a box/does not have a box. Where does it go?

[*If the pupil is placing the cards correctly, do not repeat the rule. If he/she gets a card wrong, simply repeat the rule* "Remember, if there's a box, play the colour game. If there's no box, play the shape game. This card has a box/does not have a box. Where does it go?"]

[*Continue until the pupil reaches the black break card. Record below where the pupil places each card. DO NOT inform the pupil whether the choice is correct or not*]

Card	**Target Card – Green Goat**	**Target Card – Yellow Moto**
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

5. Timed Box Trials

Okay, you played really well. Now, I would like you to play one more round but this time I want you to sort the cards as quickly and as accurately as you can. The rules are the same. If you see cards with a black box, you have to play the colour game. In the colour game, yellow ones go here and green ones go there [*pointing to the appropriate places*]. But if the cards have no black box, you have to play the shape game. In the shape game, if it's a goat, we put it here, but if it's a moto, we put it there [*pointing to the appropriate places*].

To help you remember the rules, you can look at this card which shows that the box means you're playing the colour game, but no black box means you're playing the shape game [*Point at the appropriate guidance diagram on the card*]

You will need to turn over the cards yourself. Remember that you need to place them as quickly as you can. Are you ready?

[*Ensure you have the stop watch ready to start*]

OK, GO!

[*Start timing the task. When the pupil places the last card, stop the watch*]

Card	**Target Card – Green Goat**	**Target Card – Yellow Moto**
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		

Time	**Errors (do not complete)**	**Score (do not complete)**

OK, thank you. Do you like stickers? [*If he/she says 'yes', say*] Here's a sticker for completing this game.

Comments/Notes

D2. OBJECT-BASED PATTERN REASONING ASSESSMENT

<u>Let's play a different kind of game now. Let's get up from the table.</u>

<u>In this game, I'm going to show you a series of patterns. Here's the first one.</u>

[*Point at the first pattern on the floor*]

<u>Which one of these do you think goes here?</u>

[*Point to the empty place in the pattern, then show the pupil the options. When the pupil places or indicates the object, mark the response on the score sheet using the following codes*

- BD – Blue bead
- BN – Bean
- GD – Green bead
- GBT – Green bottle top
- RBT – Red bottle top
- ST – Stone
- TA-TL – Tile A to Tile L
- TP – Toothpick
- WB – Wooden block]

<u>OK, let's do another one. Which one of these do you think goes here?</u>

A.

Blue Bead	Blue Bead	Blue Bead	Blue Bead	?	Blue Bead

Available options: Blue bead, green bead, stone, bean (4)

B.

Bean	Blue Bead	Bean	Blue Bead	?	Blue Bead

Available options: Bean, blue bead, green bead, stone (4)

C.

Stone	Bean	?	Bean	Stone	Bean

Available options: Bean, blue bead, green bead, stone (4)

D.

Blue Bead	?	Stone	Stone	Toothpick	Blue Bead

Available options: Blue bead, toothpick, stone, bean (4)

E.

Toothpick	Toothpick	Bean	?	Wooden Block	Wooden Block

Available options: Blue bead, toothpick, stone, bean, wooden block, red bottle top (6)

F.

Red Bottle Top	Bean	?	Stone	Bean	Red Bottle Top

Available options: Bean, wooden block, red bottle top, green bottle top, stone, toothpick (6)

G.

Red Bottle Top	Bean	Wooden Block	Red Bottle Top	Bean	?

Available options: Red bottle top, toothpick, blue bead, green bead, wooden block, stone (6)

H.

Bean	Bean	Toothpick	Toothpick	?	Green Bottle Top

Available options: Bean, wooden block, red bottle top, green bottle top, stone, blue bead (6)

I.

Tile 1	Tile 2	Tile 3	Tile 4	Tile 5	?

Available options: Tile A, Tile B, Tile C, Tile D, Tile E and Tile F (6)

J.

Tile 6	?	Tile 7	Tile 8	Tile 9	Tile 10

Available options: Tile G, Tile H, Tile I, Tile J, Tile K and Tile L (6)

Thank you. Here's another sticker!

Comments/Notes

D3. FLEXIBLE ITEM SELECTION TASK

Guidelines

[*For this game, sit to the side of the pupil (but do not let him/her see your record sheet/tablet!) Throughout, if the pupil selects only one box remind him/her with "*Remember, you need to select two boxes to make a pair, not just one!*"*
Box A is the box at the top of each card; Box C or D is at the bottom]

We're now going to play a different game. In this game, you are going to see some more boxes with pictures in them.

Demonstration Trial

Look! [*Turn over Card D-1*] Here's a card with four boxes on it – here's one box, here's another, and another, and another. I'm going to pick two boxes that are the same in one way. So I'll pick these two boxes [*simultaneously pointing to two identical boxes, that is, Box A and Box D*]. These two boxes are the same because they both have one small red shoe in them. So they're the same. Now I'm going to pick two boxes that are the same but in a different way. So I'll pick these two boxes [*simultaneously pointing to the other pair of identical boxes, that is, Box B and Box C*]. These two boxes are the same because they both have two medium blue cups in them. That's why they're the same. So these two boxes are the same [*pointing to the first pair*] and these two boxes are the same [*pointing to the second pair*], but see, these two boxes here are different from those two boxes.

Criterial Trials

Here's another card with some more boxes. [*Turn over Card C-1, also containing four boxes*] Now, I am going to point to two boxes that are the same in some way that is not like the other boxes, but the way the two boxes are the same is different from the other boxes – so, two boxes that are the same but different from the other boxes [*Point to Box A and Box C each showing a large yellow chicken*]. Now, I would like you to show me the two boxes that are the same in another way that is different from the other boxes – so, two boxes that are the same but different from the other boxes.

[*The pupil should point at Boxes B and D, each showing three small red cups. If he/she does, say* "Good, well done. Those two boxes match because they both contain three small red cups". *If he/she doesn't point at Boxes B and D, i.e. he/she picks different boxes, say* "Here, look! These two boxes match because they both contain three small red cups."]

Here's another card with some more boxes. [*Turn over Card C-2, also containing four boxes*] Now, I am going to point to two boxes that are the same in some way that is not like the other boxes, but the way the two boxes are the same is different from the other boxes – so, two boxes that are the same but different from the other boxes [*Point to Box B and Box C each showing three large red chickens*]. Now, I would like you to show me the two boxes that are the same in another way that is different from the other boxes – so, two boxes that are the same but different from the other boxes.

[*The pupil should point at Boxes A and D, each showing two medium-sized yellow shoes. If he/she does, say* "Good, well done. Those two boxes match because they both contain two medium yellow shoes". *If he/she doesn't point at Boxes A and D, i.e. he/she picks different boxes, say* "Here, look! These two boxes match because they both contain two medium yellow shoes."]

Let's do another one. Now this one is a little different. [*Turn over Card 2M-D, which contains three boxes*] Now, I am going to point to two boxes that are the same in some way that is not like the other box. [*Point to Box A and Box B showing a large blue shoe and a large yellow shoe respectively*] See, these two boxes are the same but different from the other box. Now, I would like you to point to two boxes that are the same in another way, that is different from the other box – so, two boxes that are the same but different from the other box.

[*The pupil should point at Box A and Box C showing a large blue shoe and one large blue chicken respectively. If the pupil failed to identify at least one of the matches on Cards C-1 and C-2 correct boxes and fails to point to these two boxes on Card 2M-D, move on to the next game (D4 – Tower of Hanoi). If the pupil correctly paired the correct boxes on Cards C-1 or C-2 but does not identify the correct boxes on Card 2M-D, say* "Here, look! These two boxes match because they both contain large shoes [*point at Boxes A and B*] while these two boxes match [*point at Boxes A and C*] because the objects are blue." *If the pupil correctly pairs the boxes, say* "Yes, you know how to play this game. These two boxes match because they both contain large shoes [*point at Boxes A and B*] while these two boxes match [*point at Boxes A and C*] because the objects are blue."]

Let's do some more. Now it's your turn to match the boxes.

2-Match Trials

[*Turn over Card 2M-1*]

Now, I would like you to point to two boxes on this card that are the same in some way that is not like the other box and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two different boxes on this card that are the same in one way, but different to the other box. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card*]

Card 2M-1 - Correct Matches (tick as correct)

- Boxes A and C ☐ Reason – match on colour (blue) ☐
- Boxes B and C ☐ Reason – match on shape (cup) ☐

Card 2M-1 – Incorrect Matches (score/count as they occur)

Match irrelevant (Boxes A and B)	
Match same (already matched)	
No response	

Let's do another.

[*Turn over Card 2M-2*]

Now, I would like you to point to two boxes on this card that are the same in some way that is not like the other box and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two different boxes on this card that are the same in one way, but different to the other box. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card*]

Card 2M-2 - Correct Matches (tick as correct)

- Boxes A and B ☐ Reason – match on size (medium) ☐
- Boxes B and C ☐ Reason – match on number (three) ☐

Card 2M-2 – Incorrect Matches (score/count as they occur)

Match irrelevant (Boxes A and B)	
Match same (already matched)	
No response	

Let's do another.

[*Turn over Card 2M-3*]

Now, I would like you to point to two boxes on this card that are the same in some way that is not like the other box and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two different boxes on this card that are the same in one way, but different to the other box. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card*]

Card 2M-3 - Correct Matches (tick as correct)

- Boxes A and B ☐ Reason – match on number (one) ☐
- Boxes A and C ☐ Reason – match on shape (chicken) ☐

Card 2M-3 – Incorrect Matches (score/count as they occur)

Match irrelevant (Boxes B and C)	
Match same (already matched)	
No response	

Let's do another.

[*Turn over Card 2M-4*]

Now, I would like you to point to two boxes on this card that are the same in some way that is not like the other box and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two different boxes on this card that are the same in one way, but different to the other box. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card*]

Card 2M-4 - Correct Matches (tick as correct)

- Boxes A and B ☐ Reason – match on colour (red) ☐
- Boxes B and C ☐ Reason – match on shape (shoe) ☐

Card 2M-4 – Incorrect Matches (score/count as they occur)

Match irrelevant (Boxes A and C)	
Match same (already matched)	
No response	

Let's do another.

[*Turn over Card 2M-5*]

First, I would like you to point to two boxes on this card that are the same in some way that is not like the other box and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two different boxes on this card that are the same in one way, but different to the other box. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card*]

Card 2M-5 - Correct Matches (tick as correct)

- Boxes A and C ☐ Reason – match on colour (yellow) ☐
- Boxes B and C ☐ Reason – match on number (two) ☐

Card 2M-5 – Incorrect Matches (score/count as they occur)

Match irrelevant (Boxes A and B)	
Match same (already matched)	
No response	

Let's do another.

[*Turn over Card 2M-6*]

Now, I would like you to point to two boxes on this card that are the same in some way that is not like the other box and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two different boxes on this card that are the same in one way, but different to the other box. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card*]

Card 2M-6 - Correct Matches (tick as correct)

- Boxes A and C ☐ Reason – match on shape (cup) ☐
- Boxes B and C ☐ Reason – match on size (large) ☐

Card 2M-6 – Incorrect Matches (score/count as they occur)

Match irrelevant (Boxes A and B)	
Match same (already matched)	
No response	

4-Match Trials

[*Turn over Card 4M-D*]

Now this one is a little different. Here are four boxes again. You can match these boxes in four different ways. First, I can match these two [*point at Box A and Box B*] because the items are both medium sized. Second, I can match these two [*point at Box A and Box C*] because the items are shoes. Thirdly, I can match these two [*point at Box B and Box D*] because the items are red. Finally, I can match these two [*point at Box C and Box D*] because there are two items in each.

Now it's your turn to match the boxes. [*Turn over card 4M-1*] First, I would like you to point to two boxes on this card that are the same in some way that is not like the other boxes and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.

Now, please point to two boxes on this card that are the same in another way, but different to the other boxes. Please tell me why they're the same.

Now, I would like you to do the same thing, to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card. If the pupil hesitates for a prolonged period, ask* "Ask you done?" *and, if so, move to the next card, marking 'No response' below*]

Card 4M-1 - Correct Matches (tick as correct)

- Boxes A and D ☐ Reason – match on size (large) ☐
- Boxes A and B ☐ Reason – match on shape (cup) ☐
- Boxes B and C ☐ Reason – match on colour (yellow) ☐
- Boxes B and D ☐ Reason – match on number (three) ☐

Card 4M-1 – Incorrect Matches (score/count as they occur)

Match irrelevant	
Match same (already matched)	
No response	

Let's do another.

[*Turn over card 4M-2*]

First, I would like you to point to two boxes on this card that are the same in some way that is not like the other boxes and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.

Now, please point to two boxes on this card that are the same in another way, but different to the other boxes. Please tell me why they're the same.

Now, I would like you to do the same thing, to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card. If the pupil hesitates for a prolonged period, ask* "Ask you done?" *and, if so, move to the next card, marking 'No response' below*]

Card 4M-2 - Correct Matches (tick as correct)

- Boxes A and D ☐ Reason – match on number (one) ☐

- Boxes A and C ☐ Reason – match on size (small) ☐
- Boxes B and D ☐ Reason – match on colour (blue) ☐
- Boxes C and D ☐ Reason – match on shape (chicken) ☐

Card 4M-2 – Incorrect Matches (score/count as they occur)

Match irrelevant	
Match same (already matched)	
No response	

Let’s do another.

[*Turn over card 4M-3*]

First, I would like you to point to two boxes on this card that are the same in some way that is not like the other boxes and to tell me why they’re the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they’re the same.

Now, please point to two boxes on this card that are the same in another way, but different to the other boxes. Please tell me why they’re the same.

Now, I would like you to do the same thing, to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they’re the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card. If the pupil hesitates for a prolonged period, ask* “Ask you done?” *and, if so, move to the next card, marking ‘No response’ below*]

Card 4M-3 - Correct Matches (tick as correct)

- Boxes A and C ☐ Reason – match on colour (red) ☐
- Boxes A and D ☐ Reason – match on shape (shoe) ☐
- Boxes A and B ☐ Reason – match on size (medium) ☐
- Boxes A and D ☐ Reason – match on number (one) ☐

Card 4M-3 – Incorrect Matches (score/count as they occur)

Match irrelevant	
Match same (already matched)	
No response	

Let’s do another.

[*Turn over card 4M-4*]

First, I would like you to point to two boxes on this card that are the same in some way that is not like the other boxes and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.

Now, please point to two boxes on this card that are the same in another way, but different to the other boxes. Please tell me why they're the same.

Now, I would like you to do the same thing, to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card. If the pupil hesitates for a prolonged period, ask* "Ask you done?" *and, if so, move to the next card, marking 'No response' below*]

Card 4M-4 - Correct Matches (tick as correct)

- Boxes A and B ☐ Reason – match on colour (yellow) ☐
- Boxes A and C ☐ Reason – match on number (three) ☐
- Boxes B and D ☐ Reason – match on shape (cup) ☐
- Boxes C and D ☐ Reason – match on size (large) ☐

Card 4M-4 – Incorrect Matches (score/count as they occur)

Match irrelevant	
Match same (already matched)	
No response	

Let's do another.

[*Turn over card 4M-5*]

First, I would like you to point to two boxes on this card that are the same in some way that is not like the other boxes and to tell me why they're the same. [*Record matches below. After the first match, say*]

Now, I would like you to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.

Now, please point to two boxes on this card that are the same in another way, but different to the other boxes. Please tell me why they're the same.

Now, I would like you to do the same thing, to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card. If the pupil hesitates for a prolonged period, ask* "Ask you done?" *and, if so, move to the next card, marking 'No response' below*]

Card 4M-5 - Correct Matches (tick as correct)

- Boxes A and C ☐ Reason – match on colour (blue) ☐
- Boxes A and D ☐ Reason – match on number (one) ☐
- Boxes B and C ☐ Reason – match on shape (chicken) ☐
- Boxes B and D ☐ Reason – match on size (small) ☐

Card 4M-5 – Incorrect Matches (score/count as they occur)

Match irrelevant	
Match same (already matched)	
No response	

<u>Let's do another.</u>

[*Turn over card 4M-6*]

<u>First, I would like you to point to two boxes on this card that are the same in some way that is not like the other boxes and to tell me why they're the same.</u> [*Record matches below. After the first match, say*]

<u>Now, I would like you to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.</u>

<u>Now, please point to two boxes on this card that are the same in another way, but different to the other boxes. Please tell me why they're the same.</u>

<u>Now, I would like you to do the same thing, to point to two boxes on this card that are the same in another way, but different to the other boxes. Again, please tell me why they're the same.</u>

[*If the pupil chooses an incorrect match, explain why the match is incorrect and move onto the next card. If the pupil hesitates for a prolonged period, ask* <u>"Ask you done?"</u> *and, if so, move to the next card, marking 'No response' below*]

Card 4M-6 - Correct Matches (tick as correct)

- Boxes A and C ☐ Reason – match on number (two) ☐
- Boxes A and D ☐ Reason – match on shape (shoe) ☐
- Boxes B and D ☐ Reason – match on colour (red) ☐
- Boxes B and C ☐ Reason – match on size (medium) ☐

Card 4M-6 – Incorrect Matches (score/count as they occur)

Match irrelevant	
Match same (already matched)	
No response	

Well done. Here's another sticker!

Comments/Notes

D4. TOWER OF HANOI

[*Sit FACING the pupil. For the set-up, all disks are off the pegs.*
To count as a move, the disk must be lifted completely off its starting peg AND placed (i.e. dropped fully) on a peg (the same or a different peg).
Count all illegal moves completed (e.g. a large disk being placed on top of a smaller disk) but only notify the pupil when they are actually making the illegal move (not before it)]

We're going to play another game now.

Introduction

In this game, the aim is to move all of the disks to this peg [*point to the pupil's right peg*].

You can use all three pegs but the rules are that you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, disks must stay on the pegs unless you are moving them and you must only use one hand to move the disks.

Before we start the game, can you show me which of these two disks is larger? [*hold up both disks*]

Good. And let me check, can a larger disk go on top of a smaller disk?

[*Place the large disk on top of the small disk*]

No! That move isn't allowed. You can only put the smaller disk on top of a larger disk.

2-Disk Practice

Let's start off with just two disks.

[*Place both disks on the pupil's left peg*]

Remember you want to move all disks to the end peg using as few moves as possible. You can use all three pegs but you must only move one disk at a time, you can never place a larger disk on top of a smaller disk, disks must stay on the pegs unless you are moving them and you must only use one hand to move the disks.

Remember that you want to use as few moves as possible! OK, please go ahead.

[*Give the pupil one minute to complete the two-disk challenge.*

If the pupil violates any of the rules, point this out and repeat "Remember the rules – you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, and disks must stay on the pegs unless you are moving them."

If he/she does not complete the task in that time, say "OK, let me show you how it can be done" *and complete the task for them, then ask them to do it themselves*]

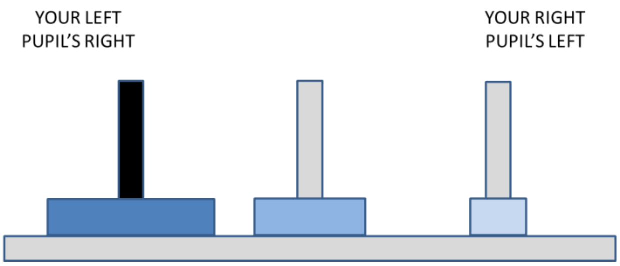
Good job.

3-Disk Trials

OK, we're now going to do the same thing, but with an extra disk [*add the third disk*]. Remember that you want to move all the disks to the end peg but this time you're going to start from different positions. Here's a picture of how you want the disks to look [*show the pupil the photograph*]

Trial A

[*Set up the disks as indicated below. When ready, repeat the rules*]



Remember the rules – you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, disks must stay on the pegs unless you are moving them, and you can only use one hand to move the disks.

Remember also to use as few moves as possible. Do you understand or shall I repeat the rules?

Good. Are you ready?

OK, GO.

[*Mark the number of moves used below. Give the pupil up to ONE minute to complete the task. If he/she doesn't complete within such time, terminate the task. In either case, count the total number of moves.*]

Trial	Move Count	Illegal Moves	Other Violations	Completed?
A				

[*If the pupil completed the task in TWO moves within the allocated time, proceed to Trial B. Otherwise, say to the pupil either*]

OK, you didn't complete that task quickly enough.

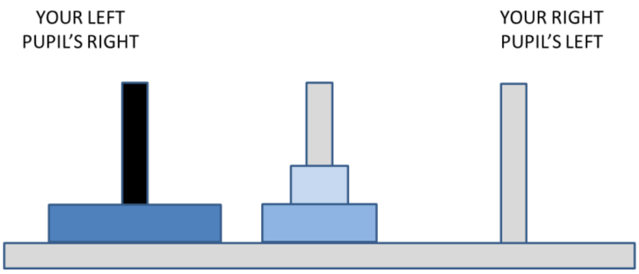
OR

OK, you completed the task using [*state the number of moves used*] moves. Please remember to use as few moves as possible.

Let's try another version.

Trial B

[*Set up the disks as indicated below. When ready, repeat the rules*]



Remember the rules – you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, disks must stay on the pegs unless you are moving them, and you can only use one hand to move the disks.

Remember also to use as few moves as possible. OK, please go ahead.

[*Mark the number of moves used below. Give the pupil up to ONE minute to complete the task. If he/she doesn't complete within such time, terminate the task. In either case, count the total number of moves.*]

Trial	**Move Count**	**Illegal Moves**	**Other Violations**	**Completed?**
B				

If the pupil completed the task in THREE moves within the allocated time, proceed to Trial C. Otherwise, say to the pupil either]

OK, you didn't complete that task quickly enough.

OR

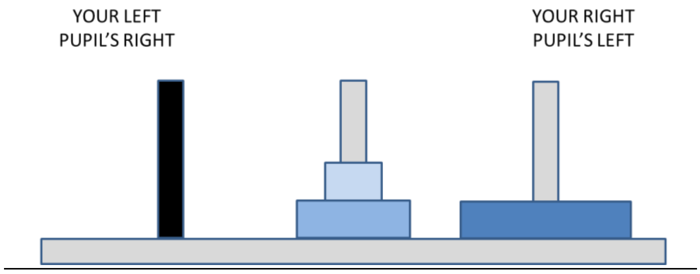
OK, you completed the task using [*state the number of moves used*] moves. Please remember to use as few moves as possible.

[*If he/she completed either Trial A or B, move to Trial C. If he/she failed to complete both A and B, terminate the activity and move to D5 - Reading]*

Let's try another version.

Trial C

[*Set up the disks as indicated below. When ready, repeat the rules*]



Remember the rules – you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, disks must stay on the pegs unless you are moving them, and you can only use one hand to move the disks.

Remember also to use as few moves as possible. OK, please go ahead.

[*Mark the number of moves used below. Give the pupil up to ONE minute to complete the task. If he/she doesn't complete within such time, terminate the task. In either case, count the total number of moves.*]

Trial	**Move Count**	**Illegal Moves**	**Other Violations**	**Completed?**
C				

If the pupil completed the task in FOUR moves within the allocated time, proceed to Trial D. Otherwise, say to the pupil either]

OK, you didn't complete that task quickly enough.

OR

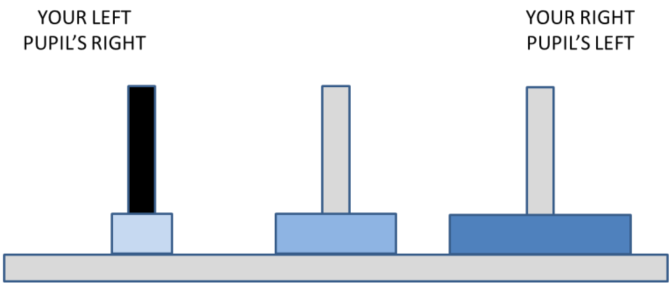
OK, you completed the task using [*state the number of moves used*] moves. Please remember to use as few moves as possible.

[*If he/she completed one or both of Trials B or C, move to Trial D. If he/she failed to complete both B and C, terminate the activity and move to D5 - Reading]*

Let's try another version.

Trial D

[*Set up the disks as indicated below. When ready, repeat the rules*]



Remember the rules – you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, disks must stay on the pegs unless you are moving them, and you can only use one hand to move the disks.

Remember also to use as few moves as possible. OK, please go ahead.

[*Mark the number of moves used below. Give the pupil up to TWO minutes to complete the task. If he/she doesn't complete within such time, terminate the task. In either case, count the total number of moves.*]

Trial	Move Count	Illegal Moves	Other Violations	Completed?
D				

If the pupil completed the task in FIVE moves within the allocated time, proceed to Trial E. Otherwise, say to the pupil either]

OK, you didn't complete that task quickly enough.

OR

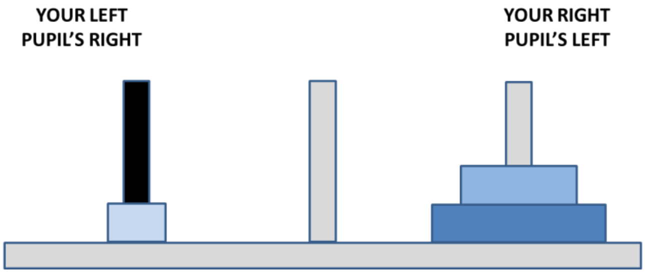
OK, you completed the task using [*state the number of moves used*] moves. Please remember to use as few moves as possible.

[*If he/she completed one or both of Trials C and D, move to Trial E. If he/she failed to complete both C and D, terminate the activity and move to D5 - Reading]*

Let's try another version.

Trial E

[*Set up the disks as indicated below. When ready, repeat the rules*]



Remember the rules – you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, disks must stay on the pegs unless you are moving them, and you can only use one hand to move the disks.

Remember also to use as few moves as possible. OK, please go ahead.

[*Mark the number of moves used below. Give the pupil up to TWO minutes to complete the task. If he/she doesn't complete within such time, terminate the task. In either case, count the total number of moves.*]

Trial	Move Count	Illegal Moves	Other Violations	Completed?
E				

If the pupil completed the task in SIX moves within the allocated time, proceed to Trial F. Otherwise, say to the pupil either]

OK, you didn't complete that task quickly enough.

OR

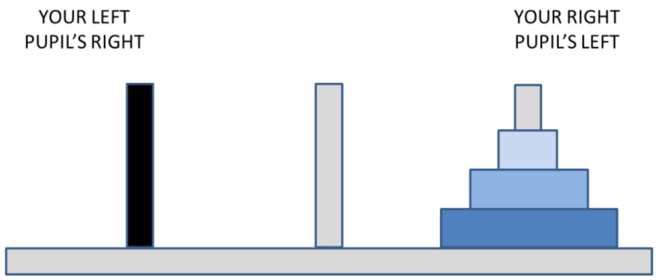
OK, you completed the task using [*state the number of moves used*] moves. Please remember to use as few moves as possible.

[*If he/she completed one or both of Trials D or E, move to Trial F. If he/she failed to complete both D and E, terminate the activity and move to D5 - Reading]*

Let's try another version.

Trial F

[*Set up the disks as indicated below. When ready, repeat the rules*]



Remember the rules – you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, disks must stay on the pegs unless you are moving them, and you can only use one hand to move the disks.

Remember also to use as few moves as possible. OK, please go ahead.

[*Mark the number of moves used below. Give the pupil up to THREE minutes to complete the task. If he/she doesn't complete within such time, terminate the task. In either case, count the total number of moves.*]

Trial	Move Count	Illegal Moves	Other Violations	Completed?
F				

OK, I'd now like you to do the same thing again and using as few moves as possible. But this time, I'd also like you to do it as quickly as possible.

[*Reset the disks to the starting points and give the pupil up to THREE minutes to complete the task. Start the stop watch with one hand, and with the other count on the sheet how many moves the pupil makes. Please ensure to stop timing as soon as the pupil successfully completes the task (even if this means that you mark the final move after the timing has ended). If the pupil does not complete the task within THREE minutes, terminate the trial and move onto the next activity (D5 – Reading)]*

4-Disk Trial

Thank you. We're nearly there!

Next, I would like you to do the same thing, as quickly as possible, but with one extra disk. I'll tell you when you can start. [*Place the new disk on top of the other disks and ensure the disks are on the pupil's left peg*]. Please complete the task as quickly as possible but using as few moves as you can. Here's a picture of how you want the disks to look [*show the pupil the appropriate photograph*]

Remember the rules – you can only move one disk at a time, you can never place a larger disk on top of a smaller disk, you must only use one hand to move the disks, and disks must stay on the pegs unless you moving them.

Are you ready? OK, GO.

[*Give the pupil up to FOUR minutes to complete the task. Start the stop watch with one hand, and with the other count on the sheet how many moves the pupil makes. Please ensure to stop timing as soon as the pupil successfully completes the task (even if this means that you mark the final move after the timing has ended)*]

Trial	**Move Count**	**Illegal Moves**	**Other Violations**	**Completed?**
4-Disks				

Well done. Here's another sticker!

Comments/Notes

D5. Reading

OK, now I'd like to do a few exercises with you to see how your reading skills in Kinyarwanda are progressing.

[*Turn to and start D5a Letter-Sound Activity (marked 'Icyiciro cya 2: Kumenya ijwi ry'inyuguti'). If the pupil achieves FOUR or more letters correct, move on to activity D5b; otherwise proceed to D5e*]

[*Turn to and start D5b Familiar Word Fluency Activity (marked 'Icyiciro cya 4. Gusoma amagambo azwi cyane'). If the pupil achieves FOUR or more words correct, move on to activity D5c; otherwise proceed to D5e*]

[*Turn to and start D5c Reading Comprehension Activities A (marked 'P1 Assessment Tool, FARS Task 1a: Oral Reading Fluency'). If the pupil reads TEN or more words correct, move on to activity D5d; otherwise proceed to D5e*]

[*Turn to and start D5d Reading Comprehension Activities B (marked 'Icyiciro cya 6a. Gusoma umwandiko' and 'Icyiciro cya 6b. Gusobanukirwa umwandiko'). Once completed, proceed to D5e*]

[*Turn to and start D5e Listening Comprehension Activity (marked 'Icyiciro cya 7. Gutega amatwi ugasobanukirwa'). Once completed, say*]

Thank you. Here's another sticker!

Comments/Notes

D5c Reading Comprehension Activities A also draws on Education Development Center, Inc. (2017).

D6. Pupil Survey

Finally, I would like to ask you some questions about life at home and your previous schooling. This will help me to know a little more about you. Remember that no one at school or home will find out your answers.

1. First, who looks after you at home? [*Do not prompt the pupil, allow him/her to answer*]

Family Member	**Tick all that apply**	**Where multiple options are possible, indicate how many (this could include step-parents, cousins etc.)**
Mother		
Father		
Brother		
Sister		
Grandmother		
Grandfather		
Uncle		
Aunt		
Cousin		
Non-relative guardian		
Other (please specify)		

2. Did you have something to drink before you came to school today, like water, tea, milk or juice?

Yes ☐ No ☐ No response/don't remember ☐

3. Did you have something to eat before you came to school today, like potatoes, rice, bread or beans?

   Yes ☐ No ☐ No response/don't remember ☐

4. How many meals do you normally eat in a day?

   One ☐ Two ☐ Three or more ☐

5. How often do you normally eat meat like beef, chicken or goat in one week?

   Everyday ☐ A few times a week ☐ Often ☐ Occasionally ☐ Rarely ☐ Never ☐

6. How often do you normally eat fish in one week?

   Everyday ☐ A few times a week ☐ Often ☐ Occasionally ☐ Rarely ☐ Never ☐

7. How often do you normally eat eggs in one week?

   Everyday ☐ A few times a week ☐ Often ☐ Occasionally ☐ Rarely ☐ Never ☐

8. How often do you normally drink milk in one week?

   Everyday ☐ A few times a week ☐ Often ☐ Occasionally ☐ Rarely ☐ Never ☐

9. What language do you mainly speak at home?

   Kinyarwanda ☐ Kirundi ☐ English ☐ French ☐
   Kiswahili ☐ Other ☐ (Specify………………) Don't know ☐

10. Do you speak any other languages at home?

    Yes ☐ No ☐ Don't know ☐

    If Yes: Which languages and how often? [*Only mark the additional languages*]

Kinyarwanda:	Everyday ☐	Often ☐	Sometimes ☐	Occasionally ☐
Kirundi:	Everyday ☐	Often ☐	Sometimes ☐	Occasionally ☐
English:	Everyday ☐	Often ☐	Sometimes ☐	Occasionally ☐
French:	Everyday ☐	Often ☐	Sometimes ☐	Occasionally ☐
Kiswahili:	Everyday ☐	Often ☐	Sometimes ☐	Occasionally ☐
Other: (specify………..)	Everyday ☐	Often ☐	Sometimes ☐	Occasionally ☐

11. Do you see [your parent(s)][your guardian(s)][the adults] reading at home?

Yes ☐ No ☐ Don't know/remember ☐

If Yes: How often do you see them reading at home?

Everyday ☐ A few times a week ☐ Often ☐ Occasionally ☐ Rarely ☐

If *Yes*: Which of your [parents][guardians] do you see reading at home?

Specify: ………………………………………………………………………………………

12. Do [your parent(s)][your guardian(s)][the adults at home] read with you?

Yes ☐ No ☐ Don't know/remember ☐

If Yes: How often do they read with you?

Everyday ☐ A few times a week ☐ Often ☐ Occasionally ☐ Rarely ☐

13. Does your family have any books at home?

Yes ☐ No ☐ Don't know/remember ☐

If Yes: I'm going to show you some cards again. Please point at the card which shows me best how many books you have at home.

[A couple of books] ☐ [Some books (6-8)] ☐ [Many books (15-20)] ☐

14. I'm going to show you a couple more cards. Which of these pictures best shows what life at home is like?

[Angry parents and stressed family] ☐ [Happy and affectionate family] ☐

15. Which of these looks most like the house where you live?

[basic house] ☐ [medium-size house] ☐ [large house] ☐

16. [FOR PUPILS IN PRIMARY 1 ONLY] Is this your first year in Primary 1, at this or any other school?

Yes ☐ No ☐ Don't know/remember ☐

If No: How many times have you been in Primary 1 before this year?

One ☐ Two ☐ Three ☐ Four or more times ☐

17. [FOR PUPILS IN PRIMARY 4 ONLY] Is this your first year in Primary 4, at this or any other school?

Yes ☐ No ☐ Don't know/remember ☐

If No: How many times have you been in Primary 4 before this year at this or any other school?

One ☐ Two ☐ Three ☐ Four or more times ☐

18. [FOR PUPILS IN PRIMARY 4 ONLY] Did you repeat any previous primary years, at this or any other school?

Yes ☐ No ☐ Don't know/remember ☐

If Yes: Which years did you repeat, at this or any other school, and how many times?

Primary 1: One ☐ Two ☐ Three ☐ Four or more times ☐

Primary 2: One ☐ Two ☐ Three ☐ Four or more times ☐

Primary 3: One ☐ Two ☐ Three ☐ Four or more times ☐

19. Do you receive any regular private tuition outside of school time from someone outside your family?

Yes ☐ No ☐ Don't know ☐

If Yes: Who tutors you?

Teacher from school ☐ Teacher from another school ☐

Other (please specify……………………) ☐

20. Before you started Primary 1 at this or any other school, did you attend any nursery or pre-primary classes?

Yes ☐ No ☐ Don't know/remember ☐

If Yes: Which of these pictures best shows what those classes were like?

[No activities/stimulation] ☐ [Formal classroom] ☐ [Play-based learning] ☐

If Yes: For how many years did you attend nursery or pre-primary classes?

One year ☐ Two years ☐ Three or more years ☐

<u>Thank you. Here's another sticker and a pencil!</u>

<u>You did a great job. You can now return to your classroom.</u>

Comments/Notes

[*After the pupil has returned to class, and before bringing the next pupil, you need to:*

- *Update the 'Language Used' response at the start if any other language was used during enumeration;*
- *Re-order the D1 Dimension Change Card Sort game cards;*
- *Reset the D2 Object-based Pattern Reasoning Assessment trials, double check that the correct items have been removed and ensure that the option items are placed so as to avoid giving any indication of the correct response; and*
- *Reset the D4 Tower of Hanoi equipment.*]

Appendix 7 – Tower of Hanoi Scoring Structure

Trial and Minimum Moves	Scoring	Maximum Score
(A) 3-disk 2 moves	0 – fail to complete within one minute 1 – complete within one minute but using extra moves 2 – complete within one minute using minimum moves with no rule violations	2
(B) 3-disk 3 moves	0 – fail to complete within one minute 1.5 – complete within one minute but using extra moves 3 – complete within one minute using minimum moves with no rule violations	3
(C) 3-disk 4 moves	0 – fail to complete within one minute 2 – complete within one minute but using extra moves 4 – complete within one minute using minimum moves with no rule violations	4
(D) 3-disk 5 moves	0 – fail to complete within one minute 2.5 – complete within one minute but using extra moves 5 – complete within one minute using minimum moves with no rule violations	5
(E) 3-disk 6 moves	0 – fail to complete within one minute 3 – complete within one minute but using extra moves 6 – complete within one minute using minimum moves with no rule violations	6
(F) 3-disk 7 moves	0 – fail to complete within two minutes 3.5 – complete within two minutes but using extra moves 7 – complete within two minutes using minimum moves with no rule violations	7
4-disk 15 moves	0 – fail to complete within two minutes 4 – complete within two minutes but using extra moves 8 – complete within two minutes using minimum moves with no rule violations	8
One point deducted for each illegal move or other rule violation		
Total Possible Score		**35**

Appendix 8 – List of Explanatory Variables

Type	Scale	Name	Description
Maturational/Pupil Factors			
Discrete	Dichotomous	Female	Whether the pupil was female or not
	Ordinal	School age	The pupil age as reported by the school
		Pupil age	The pupil age as reported by the pupil (where known)
Environmental/Home Factors			
Discrete	Dichotomous	Drank before school	Whether the pupil reported having drunk something before school that day
		Ate before school	Whether the pupil reported having eaten something before school that day
		Sees mother reading	Whether the pupil reported seeing his/her mother reading at home
		Sees father reading	Whether the pupil reported seeing his/her father reading at home
		Sees brother reading	Whether the pupil reported seeing his/her brother reading at home
		Sees sister reading	Whether the pupil reported seeing his/her sister reading at home
		Sees grandmother reading	Whether the pupil reported seeing his/her grandmother reading at home
		Sees grandfather reading	Whether the pupil reported seeing his/her grandfather reading at home
		Sees uncle reading	Whether the pupil reported seeing his/her uncle reading at home
		Sees aunt reading	Whether the pupil reported seeing his/her aunt reading at home
		Sees cousin reading	Whether the pupil reported seeing his/her cousin reading at home
		Sees non-relative guardian reading	Whether the pupil reported seeing his/her non-relative guardian reading at home
		Sees other reading at home	Whether the pupil reported seeing another person reading at home
	Nominal	Family/ environment stress	Which picture the pupil selected as representative of his/her typical home life
		House	Which picture the pupil selected as representative of his/her home
		Family structure	The pupil's family structure (e.g. single-parent, double-parent etc.)

	Ordinal	Meals per day	How many meals the pupil reported eating in a typical day
		Frequency eating meat	How often the pupil reported eating meat in a typical week
		Frequency eating fish	How often the pupil reported eating fish in a typical week
		Frequency eating eggs	How often the pupil reported eating eggs in a typical week
		Frequency drinking milk	How often the pupil reported drinking milk in a typical week
		Multilingual household	Whether the pupil reported speaking multiple languages at home
		Frequency of family reading	How often the pupil saw family members reading at home
		Family reads with child	How often the pupil reported family members reading with him/her
		Number of family readers	Number of family members the pupil reported seeing reading
		Books at home	How many books the pupil reported having at home
Educational/School Factors			
Discrete	Dichotomous	District	Which one of two districts the school was located in
		Class	Whether the pupil was in Primary 1 or Primary 4
		Tuition	Whether the pupil reported receiving regular tuition outside of school (in addition to family support with homework)
		Pre-primary	Whether the pupil reported attending any pre-primary school
		Repetition	Whether the pupil reported repeating any primary
		‘High-performing’ school	Pupil attended school classified as ‘high-performing’ according to 2016 national examination results
	Nominal	School	Which school the pupil attended
		Tutor	If the pupil receives regular tuition outside of school, the type of tutor used
		Pre-primary type	Which type of pre-primary schooling the pupil attended (if any) (includes play-based learning)
	Ordinal	Years of pre-primary	How many years of pre-primary schooling the pupil reported having undertaken
		Years of repeated primary	How many years of primary schooling the pupil reported having repeated
		Years of prior primary	How many prior years of primary schooling the pupil reported having undertaken

		Years of prior schooling	How many prior years of education (pre-primary and primary) the pupil reported having undertaken
Assessment Factors			
Discrete	Dichotomous	Co-enumeration	Whether another adult was present during the test administration
		Afternoon	Whether the assessment and survey were conducted before or after noon
	Nominal	Enumerator	Which one of four enumerators conducted the assessment and survey

Appendix 9 – Ethical Approvals

UNIVERSITY OF RWANDA **COLLEGE OF MEDICINE AND HEALTH SCIENCES**

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 6th /12/2017

Stephen Bayley
University of Cambridge

Approval Notice: No 421 /CMHS IRB/2017

Your Project Title ***"Cultivating Cognitive Competencies in Resource-Constrained Environments: A Multi-School Case Study in Rwanda"*** has been evaluated by CMHS Institutional Review Board.

		Involved in the decision		
			No (Reason)	
Name of Members	**Institute**	Yes	**Absent**	**Withdrawn from the proceeding**
Prof Kato J. Njunwa	UR-CMHS		X	
Prof Jean Bosco Gahutu	UR-CMHS	X		
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS	X		
Prof Munyanshongore Cyprien	UR-CMHS		X	
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol during the IRB meeting of where quorum was met and revisions made on the advice of the CMHS IRB submitted on 6th December 2017, **Approval has been granted to your study.**

Please note that approval of the protocol and consent form is valid for **12 months**.

You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or consent form must be submitted to the committee for review and approval, prior to activation of the changes.
2. Only approved consent forms are to be used in the enrolment of participants.
3. All consent forms signed by subjects should be retained on file. The IRB may conduct audits of all study records, and consent documentation may be part of such audits.
4. A continuing review application must be submitted to the IRB in a timely fashion and before expiry of this approval
5. Failure to submit a continuing review application will result in termination of the study
6. Notify the IRB committee once the study is finished

Sincerely,

Date of Approval: The 6th December 2017

Expiration date: The 6th December 2018

[redacted]

FS Professor Kato J. NJUNWA
Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:

- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

RESEARCH ETHICS REVIEW CHECKLIST FOR FACULTY OF EDUCATION

The Faculty's Three Stages of Ethical Clearance

Stage 1 involves you in completion of this Ethics Review Checklist. This is the first stage of three. It will help you (and others) decide to what extent you need to become involved in the second and third stages. When you have completed it you (and the Faculty) will be in a position to make this judgement.

Stage 2 will involve you in discussing any ethical dimensions of your research in some depth with your another 'knowledgeable person of standing'; this is a very likely outcome of completing the checklist. Further details are provided in Section C.

Stage 3 will involve you in obtaining formal 'ethical clearance' through the Faculty of Education's procedures; some projects will need to proceed to this stage. Further details are provided in Section C .

Most of the questions on this checklist deliberately offer you just two answers ('yes' or 'no'). You will probably find that you can answer many of the questions unequivocally one way or the other. However, sometimes you may wish there was an 'it depends' response category. If you find yourself in this position, please give the answer which suggests that, at this preliminary stage, there might be an ethical issue requiring more discussion at Stage 2.

RESEARCH ETHICS REVIEW CHECKLIST FOR FACULTY OF EDUCATION

Section A: Details of the Project

Student Name	Stephen Bayley
Email	[redacted]
Supervisor	Dr Ricardo Sabates-Aysa
Supervisor email	[redacted]
Registration Report Title	Unlocking Cognitive Competencies in Resource-Constrained Environments: A Multi-School Case Study in Rwanda

Section B: Checklist

Code of Practice relating to Educational Research		
1a	Have you read the *Revised Ethical Guidelines for Educational Research* (2011) of the British Educational Research Association (BERA)? (if you have not read it, the latest version is available at http://www.bera.ac.uk/researchers-resources/publications/bera-ethical-guidelines-for-educational-research-2011	Yes/~~No~~
1b	Is this Code relevant to the conduct of your research? If you have answered 'no', please briefly explain why:	Yes/~~No~~
1c	Do you agree to subscribe to the Code in carrying out your own research?	Yes/~~No~~
2	Are there any aspects of your proposed research which, in the context of BERA's Code of Practice, might give rise to concern amongst other educational researchers?	Yes/~~No~~
If you have answered 'yes', please briefly list possible causes for concern below:		
a	**The research will involve assessments and questionnaires for children (aged 6 to 16).**	
b		
c		
3a	Will you be analysing an existing data set that has already been collected by someone else?	~~Yes~~/No
3b	If you answered YES: can you confirm that the data you will be using is *either* Already available in the public domain for anyone to analyse Or You have been given permission by the owner of the data set to undertake your own analysis and results[1]	~~Yes/No~~ N/A

[1] *this permission should only be given if the owner of the data can make it available for secondary analysis on the basis of the*

4	Will you be collecting your own research data for the study (through such techniques as interviewing people, observing situations, issuing questionnaires etc)? ***nb. If you have answered NO to this question, you may proceed to Section C and need not answer any further questions in this section.***	Yes/~~No~~
Obtaining 'Informed Consent'		
5	Are you familiar with the concept of 'informed consent'? (if you are not familiar with this concept you should first consult the following source: page 5 of the BERA guidelines above).	Yes/~~No~~
6	Does your research involve securing participation from children, young people or adults where the concept of 'informed consent' might apply? *Permission is likely to be needed to report any information about people or institutions that is not in the public domain, and which you have been able to obtain due to your privileged access to the research site(s) in whatever capacity* [2]	Yes/~~No~~
If you have answered 'yes' to Question 6 above, please answer the following questions.		
7a	Do you believe that you are adopting suitable safeguards with respect to obtaining 'informed consent' from participants in your research in line with the Code of Practice? **All participants, including children, will receive a briefing explaining the purpose of the research and outlining their rights of withdrawal and refusal to participate. Children will be requested to provide verbal assent, while adult participants (comprising school staff/education professionals) will also receive an information sheet describing the proposed use of the data and be asked to sign a consent form.**	Yes/~~No~~
7b	Will all the information about individuals and institutions be treated on an 'in confidence' basis at all stages of your research including writing up and publication? **No individuals will be identifiable from the data/write-up/publication.**	Yes/~~No~~

informed consent they obtained from their original participants

[2] Professional work (such as teaching) can involve the collection of evidence to better understand problems/issues and to evaluate innovative practice - leaving practitioners with the question of when these activities become formal research requiring informed consent. This comment is meant to highlight how the collection of data for public reporting beyond the institution (e.g. in a thesis) should be considered as a key criterion for deciding when informed consent is required.

7c(i)	Will all the information collected about the institution(s) where research is based be presented in ways that guarantee the institution(s) cannot be identified from information provided in the report? *Note: in a thesis written by a researcher about a research context where they have a publicly acknowledged role, it is difficult to disguise the identity of the institution whilst also providing the expected detail of the researcher's relationship with the research context.*[3]	Yes/~~No~~
7c(ii)	If not, has the appropriate responsible person given approval for the research on the understanding that the identity of the institution cannot be protected in the report of the research?	~~Yes/No~~ N/A
7c(iii)	Will all the information collected about individuals be presented in ways that guarantee their anonymity? *Note: a person with a named role, or having a specific set of reported characteristics that is unique in the research context, cannot be assured of the anonymity when the identity of the research site cannot be protected.* **Any information presented about an individual school will be ambiguous on location so as to protect the anonymity of its respondents.**	Yes/~~No~~
7c(iv)	If not, have these issues been explained to the relevant participants (and appropriate gatekeepers in the case of children or other vulnerable participants)?	~~Yes/No~~ N/A
The Involvement of Adults in the Research		
8a	Will your research involve adults?	Yes/~~No~~
If you have answered 'yes' to Question 8a above, please answer the following questions; otherwise move to Question 9.		
8b	Will these adults be provided with sufficient information *prior* to agreeing to participate in your research to enable them to exercise 'informed consent'?	Yes/~~No~~

[3] At present the implicit assumption is that anonymity is always desirable*, and is always achievable. In many studies these assumptions are sound. However, a practitioner (e.g. teacher) reporting research into their own practice/institution in a thesis would normally need to be explicit about their professional relationship to the research context to give an authentic account of their research. As the staff lists of many educational institutions are in the public domain and often readily found by a web search, a thesis by a named member of staff allows the institution to be readily identified from the name of the thesis author.
Given that an institution can readily be identified, this also has consequences for the degree of anonymity that can be promised to participants - for example those with named roles such as Head of Year 11, Student Voice Coordinator, Head Prefect, etc, or those identifiable from detailed reported characteristics.
* Some institutions or participants may welcome being acknowledged by name in a thesis, and their views should be taken into account and balanced against other considerations.

8c	Will the adults involved in your research be in a position to give 'informed consent' themselves with respect to their participation?	Yes/~~No~~
8d	Will these adults be able to opt out of your research in its entirety if they wish to do so by, for example, declining to be interviewed or refusing to answer a questionnaire?	Yes/~~No~~
8e	Will these adults be able to opt out of parts of your research by, for example, declining to participate in certain activities or answer particular questions?	Yes/~~No~~
The Involvement of Children, Young People and other potentially Vulnerable Persons in the Research		
9a	Will your research involve children, young people or other potentially vulnerable persons (such as those with learning disabilities or your own students).	Yes/~~No~~
If you have answered 'yes' to Question 9a above, please answer the following questions; otherwise move to Question 10. In educational and social research 'informed consent' regarding access is often given by a 'gatekeeper' on behalf of a wider group of persons (e.g. a head or class teacher with respect to their pupils, a youth worker working with young people, another person in an 'authority' position).		
9b	Who will act as the 'gatekeeper(s)' in your research? Please list their position(s) briefly below and, where this is not self-evident, describe the nature of their relationship with those on whose behalves they are giving 'informed consent'. **The researcher cannot act as the gatekeeper (see 9g below)**	
i	**The head teacher of each public primary school selected in the sampling process**	
ii		
iii		
9c	Will you be briefing your 'gatekeeper(s)' about the nature of the questions or activities you will be undertaking with the children, young people or other potentially vulnerable persons involved in your research?	Yes/~~No~~
9d	If another person (such as a teacher or parent of a child in your study) expressed concerns about any of the questions or activities involved in your research, would your 'gatekeeper(s)' have sufficient information to provide a brief justification for having given 'informed consent'?	Yes/~~No~~
9e	If unforeseen problems were to arise during the course of the research, would your 'gatekeeper(s)' be able to contact you at relatively short notice to seek advice, if they needed to do so?	Yes/~~No~~
9f	Could your 'gatekeeper(s)' withdraw consent during the research if, for whatever reason, they felt this to be necessary?	Yes/~~No~~

9g(i)	Are you undertaking research into your own professional context/institution (e.g. with students in a school where you work)? If you answered 'Yes' then you should identify (in 9b above) a suitable senior person who has agreed to act as an independent point of contact for participants to act as the gatekeeper, and answer the following two questions:	~~Yes/~~No
9g(ii)	Will you ensure that other people in the research context are aware of the identity of the gatekeeper?	Yes/~~No~~ N/A
9g(iii)	Will you take reasonable precautions to ensure that research participants (and where appropriate their parents/guardians) know that they should contact the gatekeeper (and not you) if they have any concerns about the research?	~~Yes/No~~ N/A
Other Ethical Aspects of the Research		
10	Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (eg covert observation of people in public places)	~~Yes/~~No
11	Will the research involve the discussion of topics which some people may deem to be 'sensitive'? (e.g. sexual activity, drug use, certain matters relating to political attitudes or religious beliefs)	~~Yes~~/No
12	Does the research involve any questions or activities which might be considered inappropriate in an educational setting?	~~Yes/~~No
13	Are drugs, placebos or other substances (e.g. food substances, vitamins) to be administered to study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind? *If you have ticked 'Yes' it is vital to refer the matter to the Faculty Research Office for onward reference to the University Insurance Section.*	~~Yes/~~No
14	Will blood, tissue or other samples be taken from the bodies of participants?	~~Yes/~~No
15	Is pain or more than mild discomfort likely to result from the study?	~~Yes/~~No
16	Could the research involve psychological stress or anxiety or cause harm or negative consequences beyond the risks encountered in normal life?	~~Yes/~~No
17	Are there any other aspects of the research which could be interpreted as infringing the norms and expectations of behaviour prevailing in educational settings?	~~Yes~~/No
18	Are there any other aspects of the research which could be to the participants' detriment?	~~Yes~~/No
19	Will the study involve prolonged or repetitive testing?	~~Yes/~~No

20	Will financial inducements (other than reasonable expenses or compensation for time) be offered to participants?	~~Yes~~/No

SECTION C: Interpretation of Results

If any of your answers coincide with the response options having a coloured background, then you should assume that further discussion involving Stage 2 procedures is required because some aspect of your proposed research is likely to be 'ethically sensitive'. In practice, many issues can be resolved at this stage. In practice, many issues can be resolved at this stage.

Members of staff should be especially careful about research involving their own students (question 9g).

If you have ticked 'yes' in response to one or more of questions 10 to 20, both Stage 2 ***and*** *Stage 3 clearance will definitely be required.*

Stage 2 Clearance
Any 'ethically sensitive' responses identified above should be discussed with a 'knowledgeable person of standing'. In the case of students within the Faculty, this person will, in almost every case, be the person supervising your research.

On completion of the discussion, the 'knowledgeable person of standing' is asked to choose one of the following three responses, to delete the other two and to affirm their views by adding their signature.	
a	I have discussed the ethical dimensions of this research and, as outlined to me, I do not foresee any ethical issues arising which require further clearance.
b	There may be some ethical issues arising from this research. I think it would be prudent for the researcher to seek further advice and, possibly, Stage 3 clearance.
c	Ethical issues arise in this research which require further discussion; my advice is that Stage 3 ethical clearance sho[redacted]

Supervisor Name/ Signature	[redacted] R. SABATES .
Date	12/Oct/17.

Appendix 10 – Information Sheets and Consent Forms

Kinyarwanda versions available upon request.

INFORMATION SHEET

(FOR EDUCATION PROFESSIONALS/SCHOOL STAFF – except Head Teacher/School Management)

Cultivating Cognitive Competencies in Resource-Constrained Environments: A Multi-School Case Study in Rwanda

You have been invited to take part in a doctoral research study into primary education in Rwanda. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Purpose of the Research

The study is being undertaken as part of a PhD at the University of Cambridge, United Kingdom. The research is intended to explore how primary schooling in Rwanda fosters children's creativity (*guhanga udushya*), innovation (*ubudasa*) and problem-solving skills (*kwishakira ibisubizo*), being important 'generic' competences promoted within Rwanda's competence-based curriculum.

You have been invited to participate in the research as a teacher or other educational professional working within Rwandan primary schooling. The purpose of the study is to investigate perceptions, attitudes, teaching practices and behaviours relating to the delivery of Rwandan primary education, including the implementation of the competence-based curriculum, and how schooling fosters children's creativity, innovation and problem solving. The research is being conducted in four public primary schools in Gasabo and Nyarugenge, and a fifth school as a pilot.

Taking Part

Taking part in the research is entirely voluntary. Throughout the study, you remain free: (i) to withdraw from the research at any stage and without giving reasons; (ii) to refrain from answering any questions; and/or (iii) to request to be removed from the project and your data destroyed.

The research will be conducted in and around Kigali, Rwanda, between January and May 2018.

If you agree to participate in an interview or a classroom observation, you will be shown a copy of this information sheet and asked to sign a consent form. Interviews will be conducted in English and last a maximum of one hour.

Confidentiality

All information collected about individual participants will be kept strictly confidential (unless otherwise requested and subject to legal limitations). Responses will be recorded and stored anonymously to protect the privacy and prevent the identification of all respondents.

If you are invited and agree to be interviewed, you will be asked if the interview can be audio-recorded. A full copy of the transcript or a narrative summary can be made available for subsequent review in case you wish to check its accuracy and/or anonymity. You would also be free to switch off the recorder at any stage of the interview, without giving reasons.

If you are invited and agree to be observed, you will be asked if the observation can be video-recorded. The observation will focus on teacher behaviours and practices, and pupils in the classroom will be informed of the observation in advance and invited to sit outside the video-recording sight-line, if they would prefer. You would also be free to switch off the recorder at any stage of the observation, without giving reasons.

In due course, the anonymised findings of the study will be made available in Rwanda and published in one or more international education journals. Anonymised quantitative data may also be made available through open-access portals to enable secondary research using the data.

Costs and Benefits of Participation

The only cost to you in taking part in the research is that of your time. Observations will be completed at your place of work while interviews may be conducted at another convenient and preferable location (to be agreed in advance) to minimise your time commitment, travel expenses and disruption to your working day.

The main benefit of taking part is that you will have an opportunity to contribute to research into an important aspect of Rwandan education that may inform educational reforms in the future.

Background to the Research

The research is being undertaken by a PhD student at the University of Cambridge, United Kingdom, with supervision from the University of Rwanda and support from enumerators provided by Laterite Africa.

The study is being conducted with in accordance with the universities' ethical procedures and the British Educational Research Association guidelines (2011). If you have any concerns about the way in which the exercise is being conducted please contact Dr Ricardo Sabates at XXX in the first instance.

In the meantime, thank you for taking the time to read this information sheet.

CONSENT FORM

(FOR EDUCATION PROFESSIONALS/SCHOOL STAFF – except Head Teacher/School Management)

Cultivating Cognitive Competencies in Resource-Constrained Environments: A Multi-School Case Study in Rwanda

Thank you for agreeing to take part in the above research.

Please read the following statements carefully and sign below to indicate your consent.

1. I have had the purpose and objectives of the research explained to me and I have read and understood the Information Sheet. I understand that agreeing to take part means that I am willing:
   - to be interviewed and/or to have one or more of my classes observed;
   - for the researcher to make notes of the interview/observation(s) (as the case may be); and
   - to allow the interview/observation(s) to be video- and/or audio-recorded (delete if necessary).

2. I understand that any information I provide is confidential, and that no information that I disclose will lead to the identification of any individual.

3. I understand that I may request to see an electronic copy of my interview transcript and any notes on the classroom observation(s).

4. I understand that the interview and observation data will be anonymised.

5. I understand that my participation is voluntary, that I can choose not to participate in part or all of the research, and that I can withdraw at any stage of the project without giving a reason or being penalised or disadvantaged in any way.

6. I consent to the processing of my personal information for the purposes of this research and agree to the anonymous (unless requested otherwise) use and quotation of data produced during the interview and/or observation. I understand that such information will be treated as strictly confidential and handled in accordance with the Data Protection Act 1998 of the United Kingdom.

Name: ……………………………………………………………………

Signature: ……………………………………………………………………

Date: ……………………………………………………………………

INFORMATION SHEET

(FOR HEAD TEACHER/SCHOOL MANAGEMENT)

Cultivating Cognitive Competencies in Resource-Constrained Environments: A Multi-School Case Study in Rwanda

You and your school have been invited to take part in a doctoral research study into primary education in Rwanda. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Purpose of the Research

The study is being undertaken as part of a PhD at the University of Cambridge, United Kingdom. The research is intended to explore how primary schooling in Rwanda fosters children's creativity (*guhanga udushya*), innovation (*ubudasa*) and problem-solving skills (*kwishakira ibisubizo*), being important 'generic' competences promoted within Rwanda's competence-based curriculum.

You have been invited to participate in the research as the head teacher, principal or manager of a public primary school. The purpose of the study is to investigate perceptions, attitudes, teaching practices and behaviours relating to the delivery of Rwandan primary education, including the implementation of the competence-based curriculum, and how schooling fosters children's creativity, innovation and problem solving. The research is being conducted in four public primary schools in Gasabo and Nyarugenge, and a fifth school as a pilot.

Taking Part

Taking part in the research is entirely voluntary. Throughout the study, you, your staff and your pupils would remain free: (i) to withdraw from the research at any stage and without giving reasons; (ii) to refrain from answering any questions; and/or (iii) to request to be removed from the project and your/their data destroyed.

The research will be conducted in and around Kigali, Rwanda, between January and May 2018.

If you agree to participate in an interview, you would be asked to sign a consent form. Interviews would be conducted in English and last a maximum of one hour. Teachers and staff who agree to participate in an observation would also be shown an information sheet and asked to sign a consent form.

Pupil Participation

Part of the research involves undertaking basic assessments and questionnaires with some of your pupils. The assessments comprise several games adapted for children in Rwanda and involve the pupils completing patterns, solving problems with a basic toy and sorting cards with different shapes and colours. The pupil would also be tested on his/her basic reading skills and asked several questions about prior schooling and his/her life outside of school. Pupils would be rewarded with stickers on the completion of each task and you would be welcomed to review or participate in all assessments before their use with any pupils.

The assessments would need to be conducted in a quiet room at the school where a trained Rwandan enumerator would test each pupil individually for up to one hour. In total, the research would need to test 50 pupils from each of Primary 1 and 4 per school (a total of 100 pupils). Pupils would be selected from the class list based on their age.

Confidentiality

All information collected about individual participants would be kept strictly confidential (unless otherwise requested and subject to legal limitations). Responses would be recorded and stored anonymously to protect the privacy and prevent the identification of all respondents.

If you agree to be interviewed, you would be asked if the interview could be audio-recorded. A full copy of the transcript or a narrative summary could be made available for subsequent review in case you wished to check its accuracy and/or anonymity. You would also be free to switch off the recorder at any stage of the interview, without giving reasons.

If you and/or your colleagues are invited and agree to be observed, you/your colleagues would be asked if the observation could be video-recorded. The observation would focus on teacher behaviours and practices, and pupils in the classroom would be informed of the observation in advance and invited to sit outside the video-recording sight-line, if they would prefer. You/they would also be free to switch off the recorder at any stage of the observation, without giving reasons.

In due course, the anonymised findings of the study will be made available in Rwanda and published in one or more international education journals. Neither the school nor any individual staff or pupil would be identifiable in such publications. Such anonymised quantitative data may also be made available through open-access portals to enable secondary research using the data.

Costs and Benefits of Participation

The only cost to you in taking part in the research would be that of your, your teachers' and your pupils' time. Observations would be completed at your school while interviews may be conducted at another convenient and preferable location (to be agreed in advance) to minimise time commitment, travel expenses and disruption for you and your colleagues.

The main benefit of taking part would be that you and your school would have an opportunity to contribute to research into an important aspect of Rwandan education that may inform educational reforms in the future.

Background to the Research

The research is being undertaken by a PhD student at the University of Cambridge, United Kingdom, with supervision from the University of Rwanda and support from enumerators provided by Laterite Africa.

The study is being conducted with in accordance with the universities' ethical procedures and the British Educational Research Association guidelines (2011). If you have any concerns about the way in which the exercise is being conducted please contact Dr Ricardo Sabates at XXX in the first instance.

In the meantime, thank you for taking the time to read this information sheet.

CONSENT FORM

(FOR HEAD TEACHER/SCHOOL MANAGEMENT)

Cultivating Cognitive Competencies in Resource-Constrained Environments: A Multi-School Case Study in Rwanda

Thank you for agreeing to your school taking part in the above research.

Please read the following statements carefully and sign below to indicate your consent.

1. I have had the purpose and objectives of the research explained to me and I have read and understood the Information Sheet. I understand that agreeing to take part means that I am willing and agree:
   - for staff and pupils at the school to take part in the research (subject to their own personal rights of withdrawal and/or refusal);
   - to act as gatekeeper for the research and to answer or refer questions from (prospective) participants or others as and when they arise;
   - to be interviewed and/or to have one or more of my classes observed (if appropriate);
   - for the researcher to make notes of the interview/observation(s) (as the case may be); and
   - to allow the interview/observation to be video- and/or audio-recorded (delete if necessary).

2. I understand that any information I provide is confidential, and that no information that I disclose will lead to the identification of any individual.

3. I understand that I may request to see an electronic copy of my interview transcript and any notes on the classroom observation(s) (if appropriate).

4. I understand that the interview and observation data will be anonymised.

5. I understand that my participation is voluntary, that I can choose not to participate in part or all of the research, and that I can withdraw at any stage of the project without giving a reason or being penalised or disadvantaged in any way. I also understand that this applies to each proposed participant in the research (both staff and pupils).

6. I consent to the processing of my personal information for the purposes of this research and agree to the anonymous (unless requested otherwise) use and quotation of data produced during the interview, observation(s) and/or pupil assessments/questionnaires (as the case may be). I understand that such information will be treated as strictly confidential and handled in accordance with the Data Protection Act 1998 of the United Kingdom.

Name: ……………………………………………………………………

Signature: ……………………………………………………………………

Date: ……………………………………………………………………

OBSERVATION NOTIFICATION

(To be read to pupils in Kinyarwanda before video-recording any observations)

Good [morning/afternoon]. Today, we have a researcher visiting us from the University of Cambridge in England who would like to observe the lesson. He is looking at how Rwandan schooling supports pupils like you to be creative and innovative problem solvers.

He would like to video-record the class and has set up his camera at the back. However, if you would prefer not to be recorded, please raise your hand now and we will re-seat you out of the line of sight.

Thank you for your cooperation.

Appendix 11 – Explanatory Variables and Cognitive Flexibility

Table 11A.1 – Explanatory Variable Associations with DCCS Data – Primary 1

Variable Description	**Parametric Test**			**Non-Parametric Test**		
Dichotomous	**Independent *t*-test**			**Wilcoxon Rank-Sum Mann Whitney**		
	t	**Sig**	**Effect Size (*r*)**	***z***	**Sig**	**Effect size (*r*)**
Female	0.32	.75	0.03	0.07	.95	0.01
Private tuition	-0.13	.90	0.03	0.31	.76	0.02
Ate before school	0.36	.72	0.03	0.76	.45	0.06
Drank before school	2.72**	.01	0.22	3.01**	.00	0.24
Sees mother reading	0.44	.66	0.04	0.65	.52	0.05
Sees father reading	0.80	.42	0.07	1.36	.18	0.11
Sees brother reading	Single response			1.12	.26	0.09
Sees sister reading	No responses					
Sees grandmother reading	-6.34	.07	0.98	-2.26*	.02	-0.18
Sees grandfather reading	No responses					
Sees uncle reading	No responses					
Sees aunt reading	0.28	.78	0.02	0.26	.79	0.02
Sees cousin reading	Single response			-1.06	.29	-0.09
Sees non-relative guardian reading	No responses					
Sees other reading at home	No responses					
School district	-1.24	.22	0.10	-1.00	.32	-0.08
‘High-performing’ school	1.21	.23	0.10	0.84	.40	0.09
Repeated any primary	-0.80	.43	0.06	-0.47	.64	-0.04
Attended any pre-primary	1.97	.05	0.16	1.77	.08	0.14
Test co-enumerated	-0.32	.75	0.03	-0.50	.62	-0.04
Afternoon assessment	-1.03	.30	0.08	-0.76	.45	-0.06
Nominal	**ANOVA**			**Kruskal-Wallis**		
	F	**Sig**	**DF**	***H***	**Sig**	**DF**
Family structure	1.11	.35	3, 149	2.36	.50	3
Pre-primary type	1.73	.16	3, 149	4.27	.23	3
House type	2.52	.06	3, 149	7.10	.07	3
Family environment/stress	2.21	.11	2, 150	8.38*	.02	2

Private tutor	1.37	.29	2, 14	3.28	.19	2
School	1.91	.13	3, 149	4.25	.24	3
Enumerator	4.52**	.00	3, 149	9.80*	.02	3
Ordinal	**Pearson's Correlation Coefficient**			**Spearman's Rank Coefficient**		
	r	**Sig**		***r***	**Sig**	
Pupil age (reported by school)	.20*	.01		.20*	.01	
Meals per day	-.16*	.05		-.21*	.01	
Frequency eating meat	-.08	.34		-.06	.49	
Frequency eating fish	-.16	.05		-.15	.07	
Frequency eating eggs	-.05	.52		-.12	.15	
Frequency drinking milk	-.05	.51		-.08	.33	
Multilingual household	.09	.27		.06	.46	
Frequency of family reading	-.04	.65		-.07	.38	
Family reads with child	.01	.91		.00	.99	
Books at home	.07	.42		.01	.90	
Number of family readers	-.03	.70		-.07	.38	
Years of pre-primary	-.18*	.02		-.18*	.03	
Years of repeated primary	.08	.33		.06	.48	
Years of prior primary	.08	.33		.06	.48	
Years of prior schooling	-.16*	.05		-.17*	.04	

Source: Primary data, 2018. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 11A.2 – Explanatory Variable Associations with DCCS Data – Primary 4

Variable Description	**Parametric Test**			**Non-Parametric Test**		
Dichotomous	**Independent *t*-test**			**Wilcoxon Rank-Sum Mann Whitney**		
	t	**Sig**	**Effect Size (*r*)**	***z***	**Sig**	**Effect size (*r*)**
Female	-0.34	.74	0.03	-0.14	.89	-0.01
Private tuition	-0.19	.85	0.02	-1.08	.28	-0.09
Ate before school	0.57	.57	0.05	1.18	.24	0.10
Drank before school	0.17	.87	0.01	0.23	.82	0.02
Sees mother reading	-0.18	.85	0.01	-0.98	.33	-0.08
Sees father reading	-1.34	.18	0.15	-1.31	.19	-0.11
Sees brother reading	Single response			1.49	.14	0.12
Sees sister reading	Single response			1.49	.14	0.12
Sees grandmother reading	Single response			-1.50	.13	-0.12
Sees grandfather reading	Single response			-0.78	.44	-0.06
Sees uncle reading	Single response			-1.69	.09	-0.14
Sees aunt reading	-3.80	.11	0.95	-1.78	.07	-0.14
Sees cousin reading	No responses					
Sees non-relative guardian reading	Single response			1.49	.14	0.12
Sees other reading at home	-1.36	.40	0.80	-0.76	.45	-0.06
Repeated any primary	-0.25	.81	0.02	-0.32	.75	-0.03
Attended any pre-primary	1.63	.11	0.13	0.88	.38	0.07
School district	0.55	.58	0.04	-0.78	.44	-0.06
'High-performing' school	0.20	.84	0.02	0.33	.74	0.03
Test co-enumerated	0.41	.68	0.03	1.17	.24	0.09
Afternoon assessment	0.37	.71	0.03	0.70	.49	0.06
Nominal	**ANOVA**			**Kruskal-Wallis**		
	F	**Sig**	**DF**	***H***	**Sig**	**DF**
Family structure	3.70*	.01	3, 148	9.06*	.03	3
Pre-primary type	2.63	.05	3, 148	6.49	.09	3
House type	2.13	.10	3, 148	2.71	.44	3
Family environment/stress	2.53	.08	2, 149	4.26	.12	2
Private tutor	2.52	.11	2, 17	2.90	.23	2
School	0.57	.64	3, 149	7.16	.07	3

<table>
<tr><td>Enumerator</td><td>1.31</td><td>.27</td><td>3, 149</td><td>8.78*</td><td>.03</td><td>3</td></tr>
<tr><td>Ordinal</td><td colspan="3">Pearson's Correlation Coefficient</td><td colspan="3">Spearman's Rank Coefficient</td></tr>
<tr><td></td><td>r</td><td colspan="2">Sig</td><td>r</td><td colspan="2">Sig</td></tr>
<tr><td>Pupil age (reported by school)</td><td>-.08</td><td colspan="2">.30</td><td>-.05</td><td colspan="2">.51</td></tr>
<tr><td>Meals per day</td><td>-.02</td><td colspan="2">.79</td><td>-.09</td><td colspan="2">.27</td></tr>
<tr><td>Frequency eating meat</td><td>.01</td><td colspan="2">.95</td><td>-.00</td><td colspan="2">.96</td></tr>
<tr><td>Frequency eating fish</td><td>-.04</td><td colspan="2">.61</td><td>-.04</td><td colspan="2">.58</td></tr>
<tr><td>Frequency eating eggs</td><td>-.04</td><td colspan="2">.65</td><td>.02</td><td colspan="2">.78</td></tr>
<tr><td>Frequency drinking milk</td><td>-.03</td><td colspan="2">.76</td><td>.06</td><td colspan="2">.50</td></tr>
<tr><td>Multilingual household</td><td>.10</td><td colspan="2">.24</td><td>.13</td><td colspan="2">.10</td></tr>
<tr><td>Frequency of family reading</td><td>.08</td><td colspan="2">.35</td><td>.15</td><td colspan="2">.06</td></tr>
<tr><td>Family reads with child</td><td>-.09</td><td colspan="2">.30</td><td>-.05</td><td colspan="2">.53</td></tr>
<tr><td>Books at home</td><td>-.04</td><td colspan="2">.60</td><td>-.02</td><td colspan="2">.78</td></tr>
<tr><td>Number of family readers</td><td>.08</td><td colspan="2">.34</td><td>.16</td><td colspan="2">.05</td></tr>
<tr><td>Years of pre-primary</td><td>-.09</td><td colspan="2">.28</td><td>-.03</td><td colspan="2">.68</td></tr>
<tr><td>Years of repeated primary</td><td>-.08</td><td colspan="2">.36</td><td>-.03</td><td colspan="2">.74</td></tr>
<tr><td>Years of prior primary</td><td>-.08</td><td colspan="2">.36</td><td>-.03</td><td colspan="2">.74</td></tr>
<tr><td>Years of prior schooling</td><td>-.13</td><td colspan="2">.13</td><td>-.07</td><td colspan="2">.39</td></tr>
</table>

Source: Primary data, 2018. *p < .05, **p < .01, ***p < .001.

Table 11A.3 – Explanatory Variable Associations with FIST Data – Primary 1

Variable Description	Parametric Test			Non-Parametric Test		
Dichotomous	**Independent *t*-test**			**Wilcoxon Rank-Sum Mann Whitney**		
	t	**Sig**	**Effect Size (*r*)**	***z***	**Sig**	**Effect size (*r*)**
Female	0.54	.59	0.04	0.92	.36	0.07
Private tuition	0.51	.61	0.04	0.68	.50	0.05
Ate before school	-0.15	.88	0.01	-1.34	.18	-0.11
Drank before school	1.20	.23	0.10	0.95	.34	0.08
Sees mother reading	-0.03	.97	0.00	-0.09	.93	-0.01
Sees father reading	-1.10	.27	0.09	-1.27	.20	-0.10
Sees brother reading	Single response			-0.27	.79	-0.02
Sees sister reading	No responses					
Sees grandmother reading	10.05***	.00	0.63	1.74	.08	0.14
Sees grandfather reading	No responses					
Sees uncle reading	No responses					
Sees aunt reading	-0.36	.75	0.24	-1.03	.30	-0.08
Sees cousin reading	Single response			1.22	.22	0.10
Sees non-relative guardian reading	No responses					
Sees other reading at home	No responses					
Repeated any primary	0.52	.60	0.04	1.10	.27	0.09
Attended any pre-primary	-0.06	.95	0.00	-0.35	.72	-0.03
School district	0.69	.49	0.06	-1.33	.18	-0.11
'High-performing' school	0.37	.71	0.03	0.52	.60	0.04
Test co-enumerated	0.18	.86	0.01	-0.59	.56	-0.05
Afternoon assessment	-0.39	.70	0.03	-0.87	.39	-0.07
Nominal	**ANOVA**			**Kruskal-Wallis**		
	F	**Sig**	**DF**	***H***	**Sig**	**DF**
Family structure	1.34	.26	3, 149	6.22	.10	3
Pre-primary type	1.00	.39	3, 149	3.29	.35	3
House type	0.80	.50	3, 149	1.67	.64	3
Family environment/stress	0.53	.59	2, 150	1.46	.48	2
Private tutor	0.22	.81	2, 14	2.25	.33	2
School	0.22	.88	3, 149	2.10	.55	3

<table>
<tr><td>Enumerator</td><td>1.05</td><td>.37</td><td>3, 149</td><td>4.35</td><td>.23</td><td>3</td></tr>
<tr><td rowspan="2">Ordinal</td><td colspan="3">Pearson’s Correlation Coefficient</td><td colspan="3">Spearman’s Rank Coefficient</td></tr>
<tr><td>r</td><td colspan="2">Sig</td><td>r</td><td colspan="2">Sig</td></tr>
<tr><td>Pupil age (reported by school)</td><td>.07</td><td colspan="2">.39</td><td>.04</td><td colspan="2">.65</td></tr>
<tr><td>Meals per day</td><td>.02</td><td colspan="2">.78</td><td>.02</td><td colspan="2">.83</td></tr>
<tr><td>Frequency eating meat</td><td>-.03</td><td colspan="2">.69</td><td>.00</td><td colspan="2">.97</td></tr>
<tr><td>Frequency eating fish</td><td>-.07</td><td colspan="2">.41</td><td>-.03</td><td colspan="2">.69</td></tr>
<tr><td>Frequency eating eggs</td><td>-.01</td><td colspan="2">.87</td><td>.05</td><td colspan="2">.55</td></tr>
<tr><td>Frequency drinking milk</td><td>-.06</td><td colspan="2">.46</td><td>-.02</td><td colspan="2">.85</td></tr>
<tr><td>Multilingual household</td><td>.06</td><td colspan="2">.49</td><td>.08</td><td colspan="2">.31</td></tr>
<tr><td>Frequency of family reading</td><td>.04</td><td colspan="2">.63</td><td>.05</td><td colspan="2">.54</td></tr>
<tr><td>Family reads with child</td><td>.04</td><td colspan="2">.64</td><td>.03</td><td colspan="2">.76</td></tr>
<tr><td>Books at home</td><td>.04</td><td colspan="2">.64</td><td>.07</td><td colspan="2">.38</td></tr>
<tr><td>Number of family readers</td><td>.02</td><td colspan="2">.76</td><td>.06</td><td colspan="2">.49</td></tr>
<tr><td>Years of pre-primary</td><td>.03</td><td colspan="2">.70</td><td>.07</td><td colspan="2">.40</td></tr>
<tr><td>Years of repeated primary</td><td>-.09</td><td colspan="2">.30</td><td>-.10</td><td colspan="2">.21</td></tr>
<tr><td>Years of prior primary</td><td>-.09</td><td colspan="2">.30</td><td>-.10</td><td colspan="2">.21</td></tr>
<tr><td>Years of prior schooling</td><td>-.02</td><td colspan="2">.84</td><td>.01</td><td colspan="2">.87</td></tr>
</table>

Source: Primary data, 2018. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 11A.4 – Explanatory Variable Associations with FIST Data – Primary 4

Variable Description	**Parametric Test**			**Non-Parametric Test**		
Dichotomous	**Independent *t*-test**			**Wilcoxon Rank-Sum Mann Whitney**		
	t	**Sig**	**Effect Size (*r*)**	***z***	**Sig**	**Effect size (*r*)**
Female	-0.02	.99	0.00	0.07	.95	0.01
Private tuition	-0.69	.49	0.06	-1.25	.21	-0.10
Ate before school	-0.04	.97	0.00	-0.34	.74	-0.03
Drank before school	0.47	.64	0.04	-0.24	.81	-0.02
Sees mother reading	0.35	.72	0.03	0.54	.59	0.04
Sees father reading	1.47	.15	0.20	1.43	.15	0.12
Sees brother reading	Single response			1.40	.16	0.11
Sees sister reading	Single response			1.40	.16	0.11
Sees grandmother reading	Single response			-0.94	.35	-0.08
Sees grandfather reading	Single response			-0.36	.72	-0.03
Sees uncle reading	Single response			-1.48	.14	-0.12
Sees aunt reading	4.96**	.00	0.87	1.29	.20	0.10
Sees cousin reading	No responses					
Sees non-relative guardian reading	Single response			-0.36	.72	-0.03
Sees other reading at home	1.84	.26	0.84	1.12	.26	0.09
Repeated any primary	-0.68	.50	0.06	-0.05	.96	0.00
Attended any pre-primary	0.28	.78	0.02	0.15	.89	0.01
School district	-6.12***	.00	0.49	-5.41***	.00	-0.44
‘High-performing’ school	-0.83	.41	0.07	-0.88	.38	-0.07
Test co-enumerated	0.01	.99	0.00	0.16	.87	0.01
Afternoon assessment	-0.04	.97	0.00	-0.70	.49	-0.06
Nominal	**ANOVA**			**Kruskal-Wallis**		
	F	**Sig**	**DF**	***H***	**Sig**	**DF**
Family structure	1.02	.38	3, 148	3.47	.32	3
Pre-primary type	0.39	.76	3, 148	1.34	.72	3
House type	0.21	.89	3, 148	1.01	.80	3
Family environment/stress	0.36	.70	2, 149	0.51	.77	2
Private tutor	1.44	.26	2, 17	1.66	.44	2
School	13.17***	.00	3, 149	30.80***	.00	3

<table>
<tr><td>Enumerator</td><td>2.74*</td><td>.05</td><td>3, 149</td><td>11.87**</td><td>.01</td><td>3</td></tr>
<tr><td rowspan="2">Ordinal</td><td colspan="3">Pearson’s Correlation Coefficient</td><td colspan="3">Spearman’s Rank Coefficient</td></tr>
<tr><td>r</td><td colspan="2">Sig</td><td>r</td><td colspan="2">Sig</td></tr>
<tr><td>Pupil age (reported by school)</td><td>.12</td><td colspan="2">.14</td><td>.07</td><td colspan="2">.38</td></tr>
<tr><td>Meals per day</td><td>.04</td><td colspan="2">.66</td><td>.04</td><td colspan="2">.61</td></tr>
<tr><td>Frequency eating meat</td><td>.04</td><td colspan="2">.60</td><td>.01</td><td colspan="2">.93</td></tr>
<tr><td>Frequency eating fish</td><td>.05</td><td colspan="2">.51</td><td>.11</td><td colspan="2">.17</td></tr>
<tr><td>Frequency eating eggs</td><td>-.03</td><td colspan="2">.75</td><td>.01</td><td colspan="2">.92</td></tr>
<tr><td>Frequency drinking milk</td><td>.00</td><td colspan="2">.95</td><td>-.03</td><td colspan="2">.70</td></tr>
<tr><td>Multilingual household</td><td>-.01</td><td colspan="2">.92</td><td>.08</td><td colspan="2">.36</td></tr>
<tr><td>Frequency of family reading</td><td>-.13</td><td colspan="2">.11</td><td>-.12</td><td colspan="2">.16</td></tr>
<tr><td>Family reads with child</td><td>.06</td><td colspan="2">.46</td><td>.09</td><td colspan="2">.28</td></tr>
<tr><td>Books at home</td><td>-.11</td><td colspan="2">.16</td><td>-.12</td><td colspan="2">.15</td></tr>
<tr><td>Number of family readers</td><td>-.14</td><td colspan="2">.08</td><td>-.14</td><td colspan="2">.08</td></tr>
<tr><td>Years of pre-primary</td><td>-.03</td><td colspan="2">.78</td><td>-.03</td><td colspan="2">.75</td></tr>
<tr><td>Years of repeated primary</td><td>.07</td><td colspan="2">.39</td><td>.02</td><td colspan="2">.83</td></tr>
<tr><td>Years of prior primary</td><td>.07</td><td colspan="2">.39</td><td>.02</td><td colspan="2">.83</td></tr>
<tr><td>Years of prior schooling</td><td>.01</td><td colspan="2">.89</td><td>.00</td><td colspan="2">.97</td></tr>
</table>

Source: Primary data, 2018. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 11A.5 – Explanatory Variable Associations with Combined Cognitive Flexibility Score – Primary 1

Variable Description	**Parametric Test**			**Non-Parametric Test**		
Dichotomous	**Independent *t*-test**			**Wilcoxon Rank-Sum Mann Whitney**		
	t	**Sig**	**Effect Size (*r*)**	***z***	**Sig**	**Effect size (*r*)**
Female	0.54	.59	0.04	0.90	.37	0.07
Private tuition	0.17	.86	0.01	0.15	.88	0.01
Ate before school	0.20	.84	0.02	0.12	.91	0.01
Drank before school	2.77**	.01	0.22	2.91**	.00	0.24
Sees mother reading	0.32	.75	0.03	0.32	.75	0.03
Sees father reading	0.02	.99	0.00	0.03	.98	0.00
Sees brother reading	Single response			0.79	.43	0.06
Sees sister reading	No responses					
Sees grandmother reading	-3.79	.10	0.95	-1.26	.21	-0.10
Sees grandfather reading	No responses					
Sees uncle reading	No responses					
Sees aunt reading	0.05	.96	0.04	-0.34	.74	-0.03
Sees cousin reading	Single response			-0.48	.63	-0.04
Sees non-relative guardian reading	No responses					
Sees other reading at home	No responses					
Repeated any primary	-0.33	.74	0.03	-0.25	.80	-0.02
Attended any pre-primary	1.48	.14	0.12	1.72	.09	0.14
School district	0.58	.56	0.05	0.08	.93	0.01
‘High-performing’ school	1.14	.26	0.09	1.04	.30	0.08
Test co-enumerated	-0.15	.88	0.01	-0.30	.77	-0.02
Afternoon assessment	-1.01	.32	0.08	-1.13	.26	-0.09
Nominal	**ANOVA**			**Kruskal-Wallis**		
	F	**Sig**	**DF**	***H***	**Sig**	**DF**
Family structure	0.30	.84	3, 149	1.78	.62	3
Pre-primary type	0.75	.52	3, 149	2.99	.39	3
House type	1.96	.12	3, 149	5.84	.12	3
Family environment/stress	1.30	.28	2, 150	3.71	.16	2
Private tutor	1.39	.28	2, 14	2.95	.23	2

<table>
<tr><td>School</td><td>1.19</td><td>.32</td><td>3, 149</td><td>3.22</td><td>.36</td><td>3</td></tr>
<tr><td>Enumerator</td><td>3.78*</td><td>.01</td><td>3, 149</td><td>11.61**</td><td>.01</td><td>3</td></tr>
<tr><td>Ordinal</td><td colspan="3">Pearson’s Correlation Coefficient</td><td colspan="3">Spearman’s Rank Coefficient</td></tr>
<tr><td></td><td colspan="2">r</td><td>Sig</td><td colspan="2">r</td><td>Sig</td></tr>
<tr><td>Pupil age (reported by school)</td><td colspan="2">.19*</td><td>.02</td><td colspan="2">.18*</td><td>.02</td></tr>
<tr><td>Meals per day</td><td colspan="2">-.11</td><td>.16</td><td colspan="2">-.13</td><td>.12</td></tr>
<tr><td>Frequency eating meat</td><td colspan="2">-.08</td><td>.34</td><td colspan="2">-.04</td><td>.64</td></tr>
<tr><td>Frequency eating fish</td><td colspan="2">-.16</td><td>.05</td><td colspan="2">-.11</td><td>.16</td></tr>
<tr><td>Frequency eating eggs</td><td colspan="2">-.05</td><td>.56</td><td colspan="2">-.03</td><td>.73</td></tr>
<tr><td>Frequency drinking milk</td><td colspan="2">-.07</td><td>.36</td><td colspan="2">-.06</td><td>.45</td></tr>
<tr><td>Multilingual household</td><td colspan="2">.10</td><td>.22</td><td colspan="2">.14</td><td>.09</td></tr>
<tr><td>Frequency of family reading</td><td colspan="2">-.01</td><td>.93</td><td colspan="2">.01</td><td>.93</td></tr>
<tr><td>Family reads with child</td><td colspan="2">.03</td><td>.74</td><td colspan="2">.03</td><td>.72</td></tr>
<tr><td>Books at home</td><td colspan="2">.07</td><td>.38</td><td colspan="2">.09</td><td>.28</td></tr>
<tr><td>Number of family readers</td><td colspan="2">-.01</td><td>.89</td><td colspan="2">.01</td><td>.89</td></tr>
<tr><td>Years of pre-primary</td><td colspan="2">-.13</td><td>.12</td><td colspan="2">-.12</td><td>.13</td></tr>
<tr><td>Years of repeated primary</td><td colspan="2">.02</td><td>.85</td><td colspan="2">.03</td><td>.69</td></tr>
<tr><td>Years of prior primary</td><td colspan="2">.02</td><td>.85</td><td colspan="2">.03</td><td>.69</td></tr>
<tr><td>Years of prior schooling</td><td colspan="2">-.13</td><td>.10</td><td colspan="2">-.13</td><td>.12</td></tr>
</table>

Source: Primary data, 2018. $*p < .05$, $**p < .01$, $***p < .001$.

Table 11A.6 – Explanatory Variable Associations with Combined Cognitive Flexibility Score – Primary 4

Variable Description	**Parametric Test**			**Non-Parametric Test**		
Dichotomous	**Independent *t*-test**			**Wilcoxon Rank-Sum Mann Whitney**		
	t	**Sig**	**Effect Size (*r*)**	***z***	**Sig**	**Effect size (*r*)**
Female	-0.24	.81	0.02	0.03	.97	0.00
Private tuition	-0.59	.56	0.05	-0.85	.39	-0.07
Ate before school	0.36	.72	0.03	0.50	.62	0.04
Drank before school	0.40	.69	0.03	0.33	.74	0.03
Sees mother reading	0.11	.91	0.01	-0.05	.96	0.00
Sees father reading	0.30	.77	0.02	0.65	.52	0.05
Sees brother reading	Single response			1.69	.09	0.14
Sees sister reading	Single response			1.69	.09	0.14
Sees grandmother reading	Single response			-1.52	.13	-0.12
Sees grandfather reading	Single response			-0.74	.46	-0.06
Sees uncle reading	Single response			-1.68	.09	-0.14
Sees aunt reading	-1.65	.19	0.67	0.13	.90	0.01
Sees cousin reading	No responses					
Sees non-relative guardian reading	Single response			1.16	.25	0.09
Sees other reading at home	-0.54	.68	0.47	-0.35	.72	-0.03
Repeated any primary	-0.62	.53	0.05	-0.31	.76	-0.02
Attended any pre-primary	1.34	.18	0.14	1.44	.15	0.12
School district	-3.41***	.00	0.27	-3.23**	.00	-0.26
‘High-performing’ school	-0.41	.68	0.03	-0.13	.90	-0.01
Test co-enumerated	0.29	.77	0.02	0.73	.47	0.06
Afternoon assessment	0.23	.82	0.02	0.28	.78	0.02
Nominal	**ANOVA**			**Kruskal-Wallis**		
	F	**Sig**	**DF**	***H***	**Sig**	**DF**
Family structure	3.20*	.03	3, 148	11.38**	.01	3
Pre-primary type	2.12	.10	3, 148	8.21*	.04	3
House type	0.81	.49	3, 148	1.74	.63	3
Family environment/stress	0.86	.43	2, 149	1.51	.47	2
Private tutor	4.82*	.02	2, 17	7.49*	.02	2

<table>
<tr><td>School</td><td>3.94**</td><td>.01</td><td>3, 149</td><td>10.99*</td><td>.01</td><td>3</td></tr>
<tr><td>Enumerator</td><td>0.91</td><td>.44</td><td>3, 149</td><td>3.10</td><td>.38</td><td>3</td></tr>
<tr><td>Ordinal</td><td colspan="3">Pearson's Correlation Coefficient</td><td colspan="3">Spearman's Rank Coefficient</td></tr>
<tr><td></td><td colspan="2">r</td><td>Sig</td><td colspan="2">r</td><td>Sig</td></tr>
<tr><td>Pupil age (reported by school)</td><td colspan="2">.02</td><td>.79</td><td colspan="2">.00</td><td>.99</td></tr>
<tr><td>Meals per day</td><td colspan="2">.01</td><td>.91</td><td colspan="2">.00</td><td>.96</td></tr>
<tr><td>Frequency eating meat</td><td colspan="2">.03</td><td>.69</td><td colspan="2">.03</td><td>.75</td></tr>
<tr><td>Frequency eating fish</td><td colspan="2">.01</td><td>.93</td><td colspan="2">.04</td><td>.61</td></tr>
<tr><td>Frequency eating eggs</td><td colspan="2">-.04</td><td>.60</td><td colspan="2">-.01</td><td>.90</td></tr>
<tr><td>Frequency drinking milk</td><td colspan="2">-.02</td><td>.80</td><td colspan="2">-.03</td><td>.72</td></tr>
<tr><td>Multilingual household</td><td colspan="2">.06</td><td>.46</td><td colspan="2">.09</td><td>.29</td></tr>
<tr><td>Frequency of family reading</td><td colspan="2">-.03</td><td>.68</td><td colspan="2">-.03</td><td>.69</td></tr>
<tr><td>Family reads with child</td><td colspan="2">-.02</td><td>.83</td><td colspan="2">-.02</td><td>.80</td></tr>
<tr><td>Books at home</td><td colspan="2">-.11</td><td>.20</td><td colspan="2">-.10</td><td>.24</td></tr>
<tr><td>Number of family readers</td><td colspan="2">-.04</td><td>.62</td><td colspan="2">-.04</td><td>.62</td></tr>
<tr><td>Years of pre-primary</td><td colspan="2">-.08</td><td>.35</td><td colspan="2">-.08</td><td>.34</td></tr>
<tr><td>Years of repeated primary</td><td colspan="2">.00</td><td>.96</td><td colspan="2">-.01</td><td>.95</td></tr>
<tr><td>Years of prior primary</td><td colspan="2">.00</td><td>.96</td><td colspan="2">-.01</td><td>.95</td></tr>
<tr><td>Years of prior schooling</td><td colspan="2">-.08</td><td>.35</td><td colspan="2">-.10</td><td>.23</td></tr>
</table>

Source: Primary data, 2018. $*p < .05$, $**p < .01$, $***p < .001$.

Appendix 12 – Linear Regression Assumptions

The third regression model described in section 4.4.3 included both background and educational explanatory variables and also met the key underlying assumptions for parametric analyses, specifically a lack of multicollinearity, linearity, homoscedasticity and normality of sampling distribution.

Regarding multicollinearity, Table 12A.1 sets out the variance inflation factor (VIF) for each predictor variable. Across the table, there are several connected sets of variables which are indicated by the slightly higher VIF values. For example, the number of reported readers in one family was associated with how frequently children reported seeing such family members reading. Similarly, each enumerator was assigned to assess learners in particular schools, hence the relation between those two variables. Generally, however, the VIF values for each variable and overall, being 1.93, are within reasonable thresholds and show that there was no multicollinearity that could give rise to bias in the regression (Field, 2009).

Linearity and homoscedasticity are also important assumptions that can affect the generalisability of a model. Figure 12A.1 depicts a scatterplot of standardised residuals against fitted values and shows whether these assumptions are met for the model. Specifically, there is no curve in the graph that would suggest a lack of linearity. However, the funnelling of values on the left side of the chart indicates that the model performed better for lower values and heteroscedasticity may therefore present an issue.

The Breusch-Pagan/Cook-Weisberg test nevertheless offers a statistical test for assessing whether heteroscedasticity actually presents a problem in a model. In particular, the "test estimates the variance of Y from the average of squared values of the residuals" (Mehmetoglu & Jakobsen, 2017, p. 150). For the current regression, the null hypothesis of constant variance is supported and heteroscedasticity does not appear to pose a problem for the model, $\chi^2 = 0.01$, $p = .91$.

Table 12A.1 – VIF Values for Regression Predictor Variables

Variable	VIF	Variable	VIF
Class grade	1.33	House	
Family structure		- Basic house	1.25
- Non-relative guardians(s)	1.08	- Large house	1.38
- Non-parent family guardian(s)	1.11	Years of pre-primary	1.11
- Single-parent family	1.15	Repeated any primary	1.14
Drank before school	1.22	School	
Meals per day	1.21	- School 2	2.41
Frequency of eating fish	1.25	- School 3	2.43
Family environment (stress)	1.16	- School 4	1.74
Multilingual household	1.05	Enumerator	
Frequency of family reading	5.35	- Enumerator 2	2.53
Number of family readers	5.48	- Enumerator 3	1.86
		- Enumerator 4	3.38
		Total	**1.93**

Source: Primary data, 2018. Notes: This table shows variance inflation factors (VIFs) for each explanatory variable in the multivariate regression for Rwandan pupils' cognitive flexibility including both environmental and educational factors. The results show VIF values within reasonable thresholds, in each case being below 10.

Finally, the residuals should be normally distributed for the model to be considered valid. As with homoscedasticity, this assumption can be assessed using both graphical and numerical approaches. First, Figure 12A.2 shows a probability-probability (P-P) plot which maps the cumulative probability of the standardised residuals against the z-scores expected in a normal distribution (Field, 2009). Although there is some slight deviation away from the diagonal line, there is no consistent sagging or S-shape which would indicate significant non-normality. Second, the Shapiro-Wilk test compares scores in a sample to those in a normally distributed dataset and the test statistics suggest that the standardised residuals do not materially deviate from normality, $z = 1.19$, $p = .12$.

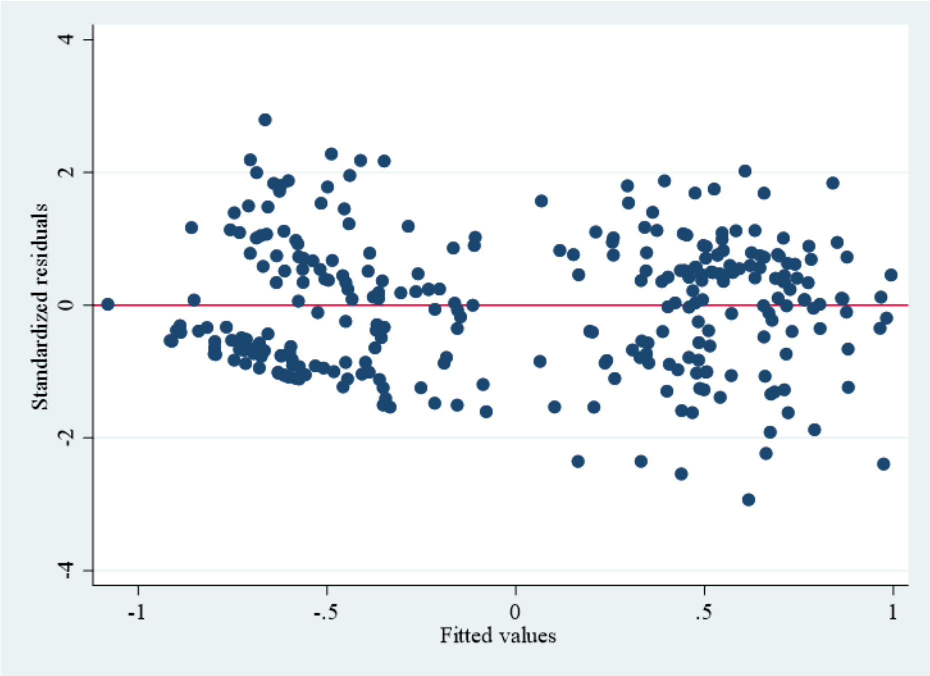


Figure 12A.1 – Scatterplot of Standardised Residuals against Fitted Values

Source: Primary data, 2018. Notes: This chart maps the regression standardised residuals against the fitted values.

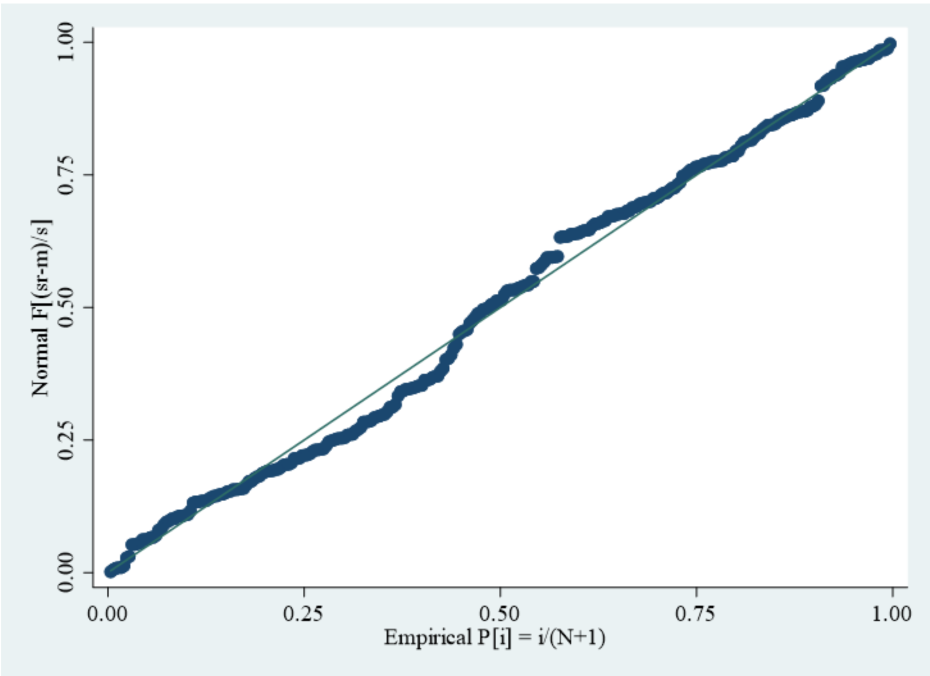


Figure 12A.2 - P-P Plot for the Standardised Residuals

Source: Primary data, 2018. Notes: This plot maps the cumulative probability of the standardised residuals against the *z*-scores expected in a normal distribution.

Appendix 13 – Literacy Assessment Statistics

Table 13A.1 – Descriptive Statistics for Literacy Assessment Tasks

Respondents	Obs	Mean	Standard Deviation	Mean – Girls	Mean – Boys	Score Range	95% Confidence Interval		*Z*-Score Range
Letter-Sound Activity – letters correctly sounded per minute (EGRA)									
Combined	306	32.83	31.79	31.36	34.06	0-105.26	29.26	36.41	-1.03-2.28
Primary 1	153	4.60	7.16	5.55	3.69	0-42.00	3.46	5.75	-1.03-0.29
Primary 4	153	61.07	19.28	61.61	60.68	0-105.26	57.99	64.14	-1.03-2.28
Familiar Word Fluency Activity – words correctly read per minute (EGRA)									
Combined	306	19.85	21.43	18.55	20.93	0-73.85	17.44	22.26	-0.93-2.52
Primary 1	153	0.56	2.56	0.95	0.18	0-21.00	0.15	0.96	-0.93-0.05
Primary 4	153	39.15	12.85	39.19	39.12	0-73.85	37.10	41.20	-0.93-2.52
Reading Comprehension Activities A – words correctly read per minute (FARS)									
Combined	157	43.93	17.56	43.88	43.96	1.00-96.51	41.16	46.69	-2.44-2.99
Primary 1	6	11.00	7.87	11.80	7.00	3.00-23.00	2.74	19.26	-2.33--1.19
Primary 4	151	45.24	16.53	46.47	44.38	1.00-96.51	42.57	47.90	-2.44-2.99
Reading Comprehension Activities A – proportion of comprehension questions correctly answered (FARS)									
Combined	157	0.92	0.16	0.89	0.94	0.45-1.00	0.89	0.94	-2.99-0.55
Primary 1	6	0.69	0.25	0.62	1.00	0.45-1.00	0.42	0.95	-2.99-0.55
Primary 4	151	0.92	0.14	0.91	0.94	0.45-1.00	0.90	0.95	-2.99-0.55
Reading Comprehension Activities B – words correctly read per minute (EGRA)									
Combined	153	41.08	15.66	39.92	41.91	2.00-82.86	38.58	43.58	-2.50-2.67
Primary 1	4	10.00	9.80	10.00	-	2.00-22.00	-5.59	25.59	-2.50--1.22
Primary 4	149	41.91	14.94	41.92	41.91	9.00-82.86	39.49	44.33	-2.05-2.67
Reading Comprehension Activities B – proportion of comprehension questions correctly answered (EGRA)									
Combined	148	0.63	0.31	0.64	0.62	0-1.00	0.58	0.68	-2.04-1.20
Primary 1	1	0.33	-	0.33	-	-	-	-	-0.96--0.96
Primary 4	147	0.63	0.31	0.65	0.62	0-1.00	0.58	0.68	-2.04-1.20
Overall Oral Reading Fluency – words correctly read per minute									
Combined	306	21.06	23.05	19.50	22.36	0-84.40	18.47	23.65	-0.91-2.75
Primary 1	153	0.51	2.42	0.85	0.18	0-22.00	0.12	0.90	-0.91-0.04
Primary 4	153	41.61	14.49	41.35	41.80	0-84.40	39.30	43.93	-0.91-2.75
Overall Reading Comprehension – proportion of questions answered correctly									
Combined	157	0.78	0.19	0.77	0.78	0.23-1.00	0.75	0.81	-2.98-1.20
Primary 1	6	0.67	0.27	0.61	1.00	0.42-1.00	0.39	0.95	-1.94-1.20
Primary 4	151	0.78	0.18	0.78	0.78	0.23-1.00	0.75	0.81	-2.98-1.20

Source: Primary data, 2018. Notes: The Letter-Sound Activity indicates the number of letters that pupils could correctly name in a minute, while the Familiar Word Fluency Activity shows the number of words in Kinyarwanda that they could read accurately in the same time. The Reading Comprehension Activities combine the number of words read correctly in one minute, as well as the proportion of comprehension questions answered successfully. The Oral Reading Fluency score takes an average of words read accurately per minute and the Reading Comprehension score takes a mean of the proportion of correct answers across the two tasks.

Table 13A.2 – Combined Correlations between Literacy Assessment Tasks and Cognitive Flexibility Measures

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Letter-Sound Activity	1.00	-	-	-	-	-	-	-	-	-	-	-	-
2. Familiar Word Fluency	.93***	1.00	-	-	-	-	-	-	-	-	-	-	-
3. Reading Fluency A	.58***	.83***	1.00	-	-	-	-	-	-	-	-	-	-
4. Reading Fluency B	.49***	.82***	.88***	1.00	-	-	-	-	-	-	-	-	-
5. Oral Reading Fluency	.92***	.98***	.96***	.96***	1.00	-	-	-	-	-	-	-	-
6. Reading Comprehension A	.09	.19*	.28***	.17*	.25**	1.00	-	-	-	-	-	-	-
7. Reading Comprehension B	.06	.24**	.27***	.35***	.31***	.17*	1.00	-	-	-	-	-	-
8. Overall Comprehension	.05	.21**	.27***	.30***	.28***	.58***	.92***	1.00	-	-	-	-	-
9. Combined Cognitive Flexibility	.64***	.64***	.19*	.14	.62***	.10	.06	.08	1.00	-	-	-	-
10. DCCS Ratio (proportion)	.42***	.40***	.09	.03	.39***	.09	.04	.08	.82***	1.00	-	-	-
11. FIST Proportion	.62***	.65***	.20*	.19*	.63***	.07	.05	.05	.82***	.35***	1.00	-	-
12. FIST Abstraction	.56***	.58***	.13	.12	.56***	.06	-.09	-.06	.76***	.31***	.93***	1.00	-
13. FIST Shifting	.61***	.64***	.22**	.20*	.63***	.07	.13	.10	.79***	.34***	.96***	.80***	1.00

Source: Primary data, 2018. *$p < .05$, **$p < .01$, ***$p < .001$. Notes: The Letter-Sound Activity indicates the number of letters that pupils could correctly name in a minute, while the Familiar Word Fluency Activity shows the number of words in Kinyarwanda that they could read accurately in the same time. The Reading Comprehension Activities combine the number of words read correctly in one minute, as well as the proportion of comprehension questions answered successfully. The Oral Reading Fluency score takes an average of words read accurately per minute and the Reading Comprehension score takes a mean of the proportion of correct answers across the two tasks. The DCCS Ratio and FIST Proportion variables show a child's proportion of correct matches across the respective tasks, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for these two variables. Further, the FIST Abstraction score represents the proportion of first matches correct across the measure and FIST Shifting denotes the proportion of subsequent matches correct also across the different rounds of the task.

Table 13A.3 – Primary 1 Correlations between Literacy Assessment Tasks and Cognitive Flexibility Measures

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Letter-Sound Activity	1.00	-	-	-	-	-	-	-	-	-	-	-	-
2. Familiar Word Fluency	.76***	1.00	-	-	-	-	-	-	-	-	-	-	-
3. Reading Fluency A	.63	.77	1.00	-	-	-	-	-	-	-	-	-	-
4. Reading Fluency B	.77	.92	.90	1.00	-	-	-	-	-	-	-	-	-
5. Oral Reading Fluency	.73***	.98***	.94**	.99**	1.00	-	-	-	-	-	-	-	-
6. Reading Comprehension A	-.32	-.52	-.02	-.48	-.28	1.00	-	-	-	-	-	-	-
7. Reading Comprehension B	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Overall Comprehension	-.37	-.58	-.11	-.57	-.37	.99***	-	1.00	-	-	-	-	-
9. Combined Cognitive Flexibility	.15	.04	.15	-.45	.03	.12	-	.16	1.00	-	-	-	-
10. DCCS Ratio (proportion)	.10	.04	-.03	-.82	.02	.13	-	.17	.84***	1.00	-	-	-
11. FIST Proportion	.14	.03	.45	.27	.03	.07	-	.08	.64***	.12	1.00	-	-
12. FIST Abstraction	.17*	.06	.49	.27	.06	.16	-	.16	.61***	.14	.92***	1.00	-
13. FIST Shifting	.08	.00	.37	.27	.00	-.04	-	-.01	.56***	.08	.91***	.68***	1.00

Source: Primary data, 2018. $*p < .05$, $**p < .01$, $***p < .001$. Notes: There was only one Primary 1 observation for the second Reading Comprehension exercise (B), hence the lack of correlation coefficients. The Letter-Sound Activity indicates the number of letters that pupils could correctly name in a minute, while the Familiar Word Fluency Activity shows the number of words in Kinyarwanda that they could read accurately in the same time. The Reading Comprehension Activities combine the number of words read correctly in one minute, as well as the proportion of comprehension questions answered successfully. The Oral Reading Fluency score takes an average of words read accurately per minute and the Reading Comprehension score takes a mean of the proportion of correct answers across the two tasks. The DCCS Ratio and FIST Proportion variables show a child's proportion of correct matches across the respective tasks, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for these two variables. Further, the FIST Abstraction represents the proportion of first matches correct across the measure and FIST Shifting denotes the proportion of subsequent matches correct also across the different rounds of the task.

Table 13A.4 – Primary 4 Correlations between Literacy Assessment Tasks and Cognitive Flexibility Measures

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Letter-Sound Activity	1.00	-	-	-	-	-	-	-	-	-	-	-	-
2. Familiar Word Fluency	.67***	1.00	-	-	-	-	-	-	-	-	-	-	-
3. Reading Fluency A	.52***	.80***	1.00	-	-	-	-	-	-	-	-	-	-
4. Reading Fluency B	.46***	.80***	.86***	1.00	-	-	-	-	-	-	-	-	-
5. Oral Reading Fluency	.60***	.92***	.96***	.95***	1.00	-	-	-	-	-	-	-	-
6. Reading Comprehension A	.00	.10	.20*	.10	.16	1.00	-	-	-	-	-	-	-
7. Reading Comprehension B	.06	.24**	.26**	.34	.30***	.15	1.00	-	-	-	-	-	-
8. Overall Comprehension	.03	.21*	.26**	.29***	.28***	.54***	.92***	1.00	-	-	-	-	-
9. Combined Cognitive Flexibility	.17*	.21*	.08	.09	.16*	.01	.05	.04	1.00	-	-	-	-
10. DCCS Ratio (proportion)	.16*	.08	.03	.03	.07	.05	.03	.06	.75***	1.00	-	-	-
11. FIST Proportion	.10	.22**	.09	.11	.17*	-.03	.04	.01	.73***	.09	1.00	-	-
12. FIST Abstraction	.06	.15	.02	.05	.10	-.04	-.11	-.11	.60***	.02	.89***	1.00	-
13. FIST Shifting	.11	.24**	.13	.14	.19*	-.02	.12	.08	.72***	.12	.96***	.73***	1.00

Source: Primary data, 2018. **p* < .05, ***p* < .01, ****p* < .001. Notes: The Letter-Sound Activity indicates the number of letters that pupils could correctly name in a minute, while the Familiar Word Fluency Activity shows the number of words in Kinyarwanda that they could read accurately in the same time. The Reading Comprehension Activities combine the number of words read correctly in one minute, as well as the proportion of comprehension questions answered successfully. The Oral Reading Fluency score takes an average of words read accurately per minute and the Reading Comprehension score takes a mean of the proportion of correct answers across the two tasks. The DCCS Ratio and FIST Proportion variables show a child's proportion of correct matches across the respective tasks, while the Combined Cognitive Flexibility score comprises an average of the standardised *z*-scores for these two variables. Further, the FIST Abstraction score represents the proportion of first matches correct across the measure and FIST Shifting denotes the proportion of subsequent matches correct also across the different rounds of the task.

Table 13A.5 – Regression Coefficients (Standard Errors) for Primary 4 Pupils' Reading Comprehension

	(1)	(2)	(3)	(4)	(5)	(6)
DCCS Ratio (proportion)	0.04 (0.10)	0.04 (0.10)	-	-	-	-
FIST Proportion	-	-	0.02 (0.11)	-0.02 (0.11)	-	-
Combined Cognitive Flexibility	-	-	-	-	0.06 (0.14)	0.02 (0.14)
Oral Reading Fluency	-	0.45 (0.14)**	-	0.46 (0.14)**	-	0.45 (0.14)**
Gender	-0.05 (0.17)	-0.06 (0.16)	-0.05 (0.17)	-0.06 (0.16)	-0.05 (0.17)	-0.06 (0.16)
Pupil age	-0.12 (0.17)	-0.06 (0.17)	-0.13 (0.17)	-0.06 (0.17)	-0.13 (0.17)	-0.07 (0.17)
Family structure						
- Non-relative guardian(s)	1.64 (1.03)	1.34 (0.99)	1.58 (1.02)	1.29 (0.99)	1.61 (1.02)	1.30 (0.99)
- Non-parent family guardian(s)	0.51 (0.36)	0.54 (0.34)	0.52 (0.35)	0.56 (0.34)	0.51 (0.36)	0.55 (0.34)
- Single parent family	0.27 (0.20)	0.25 (0.19)	0.28 (0.20)	0.27 (0.19)	0.27 (0.20)	0.26 (0.19)
Family environment (stress)	-0.91 (0.28)**	-0.78 (0.27)**	-0.92 (0.28)**	-0.79 (0.27)**	-0.91 (0.28)**	-0.79 (0.27)**
Multilingual household	-0.04 (0.07)	-0.04 (0.07)	-0.04 (0.07)	-0.04 (0.07)	-0.04 (0.07)	-0.04 (0.07)
Frequency of family reading	0.06 (0.06)	0.06 (0.06)	0.06 (0.06)	0.06 (0.06)	0.06 (0.06)	0.06 (0.06)
Number of family readers	-0.37 (0.25)	-0.36 (0.24)	-0.36 (0.25)	-0.36 (0.24)	-0.36 (0.25)	-0.36 (0.24)
House type						
- Basic house	-0.04 (0.26)	-0.05 (0.25)	-0.04 (0.26)	-0.06 (0.25)	-0.04 (0.26)	-0.06 (0.25)
- Large house	-0.04 (0.19)	0.01 (0.18)	-0.05 (0.19)	0.00 (0.18)	-0.04 (0.19)	0.00 (0.18)
School						
- School 2	-0.06 (0.28)	0.10 (0.27)	-0.06 (0.28)	0.08 (0.27)	-0.06 (0.28)	0.09 (0.27)
- School 3	-0.08 (0.27)	-0.02 (0.26)	-0.07 (0.28)	-0.04 (0.27)	-0.06 (0.27)	-0.02 (0.26)
- School 4	0.44 (0.26)	0.51 (0.25)*	0.45 (0.28)	0.49 (0.27)	0.46 (0.27)	0.52 (0.26)
Enumerator						
- Enumerator 2	-0.48 (0.31)	-0.40 (0.30)	-0.47 (0.31)	-0.39 (0.30)	-0.48 (0.31)	-0.39 (0.30)
- Enumerator 3	-0.50 (0.25)*	-0.41 (0.24)	-0.48 (0.25)	-0.41 (0.24)	-0.49 (0.25)	-0.40 (0.24)
- Enumerator 4	-0.44 (0.31)	-0.22 (0.31)	-0.42 (0.32)	-0.23 (0.31)	-0.42 (0.31)	-0.21 (0.31)
Constant	1.70 (1.87)	0.45 (1.84)	1.74 (1.87)	0.47 (1.84)	1.72 (1.87)	0.48 (1.84)
R-squared	.18	.24	.18	.24	.18	.24
Adjusted R-squared	.06	.13	.06	.13	.06	.13
Observations	148	148	148	148	148	148

Source: Primary data, 2018. *$p < .05$, **$p < .01$. Notes: This table shows the beta coefficients, standard errors and statistical significance of predictor variables in multiple regressions for Rwandan pupils' reading comprehension, based on the proportion of questions they could answer correctly. The DCCS Ratio (Proportion) and FIST Proportion variables show a child's proportion of correct matches on the respective task, while the Combined Cognitive Flexibility score comprises an average of the standardised z-scores across measures. Finally, the Oral Reading Fluency score takes an average number of words read accurately per minute.

Appendix 14 – Qualitative Themes and Codes

Research Question	Thematic Area	Code	Sub-Code(s)	Definition of (Sub-)Code	Illustrative Example from Interview Transcripts or Observation Summaries
RQ3 - What are the perceptions and attitudes of Rwandan public primary school teaching staff regarding the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	THEME 1: Individual benefits of learning	Practical skills for everyday life	Self-reliance and independence	Learning enables individuals to do things themselves and on their own	"...we have to come up with solutions ourselves without waiting or expecting anything from anyone else…"
			Originality and initiative	Learning motivates individuals to take initiative for themselves, and be original, unique and creative	"I have to give opportunity to pupils for them to be creative, to come up with new things from the lessons or from the content I taught them"
			Adaptable incomes and resilient livelihoods	Learning enables individuals to earn income, be productive and adapt to sustain themselves despite changing circumstances	"...a Rwandan who has been educated through the programme has to walk outside the school with the ability to compete, to be competitive on the labour market outside, with the ability to be able to sustain themselves…"
	THEME 2: Collective benefits of learning	Learning for social harmony and national development	Responsible citizenship	Learning provides guidance on appropriate behaviour for children and adults, not least to avoid ignorance and bad behaviour in the community	"…a child can say 'This course, I'm learning this class because it will help me to, to behave better, to manage better my money, and be a good member of the community'…"
			Nation building for the future	Education provides a basis for national development and progress	"It's all about country building. So we are building the country here. For example, today we are the main people, we are the main country builders today but tomorrow these children, these pupils will be the ones taking over…"
	THEME 3: Application to different learners	Relevance of skills	Same skills among different learners	Skills the same across different types of learners	"A child from the city is a Rwandan child and a child from the rural area is a Rwandan child and when the government is preparing the programme, only one programme gets created, elaborated"
			Difference in skills for different learners	Skills vary across different types of learners	"...they are obviously different because, they are different because of the environment. So in the education, in the education profession the environment is very influential, plays a big role…"
		Learner-based differences	Difference by gender	Relevance of gender to learners' skills	"...when you talk about gender, no, there are…that's definitely not different because they learn in one classroom…"
			Difference by location/environment	Relevance of location/environment (urban, rural) to learners' skills	"For example, in a rural area if you are teaching about environment, it's going to be much easier compared to the city."
			Difference by disability	Relevance of disability to learners' skills	"What is different is just the environment but everything else is the same and this CBC has opened doors to even the disabled, so if a child doesn't, has a problem of hearing, it's a duty to come close to them…"
			Difference by learning aptitudes	Relevance of perceived aptitude for learning ('fast'/'slow' learners)	"There is no smart child, there is no dumb child, they just have different learning capabilities."

RQ4 - What practices or behaviours are Rwandan public primary schools using to enable the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	THEME 1: Class-based activities	Dependence on age, class and subject		Activities to support learners' competencies depend on their age, grade and the subject being taught	"...probably in maths it sounds a bit difficult to promote, cannot really innovate in math but she mentioned it's a student you can give for example a student an opportunity to find another teaching material…"
		Working in groups	Organisation of groups	Teachers organise pupils into pairs or groups during lessons	"One way is to help learners, pupils learning in groups, through groups."
			Leadership of groups	Selected pupils take leadership responsibilities within the groups	"They will choose a leader and say 'You know what, we are choosing this one. You'll be our leader'."
			Benefits of group working	Advantages to pupils' learning associated with working in groups	"So pupils work together in a team and they learn collaboration."
			Risks of group working	Potential risks or disadvantages associated with pupils working in groups	"It's very hard to track a child who is a slow learner because how can you tell if a child really acquired the knowledge the child has, if it's their own."
		Use of learning aids, materials and techniques	Books	Teachers use books to foster learners' competencies	"For example, during the social studies class, what I do is take a book and a title. I give it to them and tell them to go read and then they will come afterwards telling, speaking about what they read from the book."
			ICT	Teachers draw on ICT to aid their pupils' learning	"Also about infrastructure, there will be like…we have to learn ICT but we don't have electricity in classrooms so that's bit of a challenge."
			Crafts	Pupils participate in craft activities to build their competencies	"Object production is a topic the learners use their hands, see, when they, for example, they form for example a pot or they form a cup in clay..."
			Rewards for learning and participation	Teachers use strategies to reward pupils for their participation in classes and for giving correct answers	"So the clapping is a way of…when someone does good, they get a reward. So the clapping is a way of rewarding the pupils."
			Songs, games and energisers	Teachers use songs, games, sports and other activities to nurture learners' skills and to keep them energised, focused and motivated	"So for example in music, I teach, I can come up with a song and teach the pupils the song and I encourage them again to sing it with me and also I encourage them to even create their own songs..."
		Classroom transitions	Transitions between activities	Teachers switch between different activities in the classroom	She gets them to move then distributes the 'flashcards' and tells the pupils to look at the cards in a group.
			Transitions between rules	Lesson exercises move between using different rules	The teacher says that if they've finished, they can put the fractions in a descending order.
			Transitions between languages	Teachers switch between Kinyarwanda and English	She then asks another question in Kinyarwanda and boy answers 'igikombe' (cup).
		Practical activities and application	Discussion of practical relevance	Teachers discuss with pupils the practical value, relevance and application of lessons, including any 'cross-cutting issues'	"'What would be his contribution in promoting the economy of his country?' and the boy replied that he can start a business that employs people, also adds value to the economy in general."
			Classroom practical activities	Learners participate in practical activities to build their skills and responsibility	"...children are given responsibilities early on, like they are given responsibilities to clean their classrooms, clean their playing ground."
			Outdoor practical activities	Pupils participate in outdoor activities e.g. gardening	"They also have, you know, other responsibilities like for example looking after the environment, after the gardens and flowers."
		Assessments	Formal tests and exams	Teachers use formal tests, exams and quizzes to assess pupils' skills development	"We do this through tests, we do this through testing them. Every Friday we have a test and through that we can see that a child has learnt something."
			Exercises, case studies and competitions	Pupils undertake exercises or case studies or participate in competitions to demonstrate their competencies	"So the assessment is done main-, basically through general case studies like you ask the pupil after a lesson, you ask them 'What if you are outside, you know, in everyday life and you meet certain circumstance, how would you manage?'"

RQ4 - What practices or behaviours are Rwandan public primary schools using to enable the development of their pupils' creativity, innovation and problem solving, as competencies related to their cognitive flexibility?	THEME 2: School-based activities	Clubs	Types of club	Schools involve pupils in many types of club	"...involving them in groups or clubs…yes, we have clubs of environment, clubs of against drug abuse, we have so many clubs…"
			Organisation of and participation in clubs	The organisation and eligibility for clubs varies between schools	"We have so many clubs and every club is headed by a teacher so pupils learn various skills…"
			Frequency of club meetings	Clubs meet on varied but regular bases	"I take one day, a Tue- a week, once per week for each club and they come here and we take time to celebrate, to play different games, but after we discuss, we discuss what is the importance of being here..."
		Whole-school activities	Assemblies	Schools use assemblies to develop pupils' skills	"...when they're outside on the assembly, for example we speak to them, we tell them about different topics which we, help us foster some thinking, way of thinking into them…"
			Rwandan cultural training e.g. itorero	Schools conduct trainings, such as itorero, to build learners' competencies and their understanding of Rwandan values	"We have a 40-minute period of itorero. That's where we teach pupils these competencies and values, cultural values of a Rwandan."
		External engagement	External visitors attending school	External visitors attend schools in initiatives to foster pupils' skills	"...we also receive different government officials, for example people who are in charge of the environment, sustainability and national development they come here to talk to the pupils…"
			Study visits and external competitions	Staff and pupils visit other schools to discuss and exchange practices and participate in external competitions	"And so recently we had a visit, a peer learning, students peer learning visit to another high, private school which is a fancy school, children come in cars…"
	THEME 3: Teacher support and development	Teacher training, collaboration and peer learning	Collaborative lesson planning	Teachers collaborate to plan their lessons together	"We are two teachers per every level who teach the same course, class, and we do help one another, we do support one another through lesson planning. No one does lesson planning by themselves…"
			Observations	Teachers observe one anothers' classes to improve their practice	"The other teachers observe how the teacher teaches and even the teacher who is not helping well the children in learning…so that they can improve…"
			In-school training	Schools provide different forms of training for their teachers	"The mentor can either come to you to share the knowledge or they can invite us to observe a lesson they are teaching as a demonstration and we learn from it…"
			Organisation of peer learning	Practices regarding the organisation and formality of training varies between schools	"We do this in a collaborative manner but teachers who have same course, who are in same department, those are ones who learn together."
			Frequency of collaboration and training	The frequency at which teacher collaboration, in-school training and peer learning takes place in schools	"We have one hour per week to meet, every teacher brings their teaching guides and then it's a time to, you know, to learn, to provide feedback, to talk about concerns that we have in our daily job."
	THEME 4: Desirable Changes	Improved organisation of teaching	Increased learning time	Learning time should be increased or rescheduled to better nurture pupils' competencies	"40 minutes is not enough per class session because you have to talk about cross-cutting issues, you have to talk about the content then…time is a problem."
			Smaller class sizes	Class sizes need to be reduced to improve teachers' ability to foster their learners' skills	"...it is about the big number of learners we have. We have big number of learners in each class. For example, that I take, we have for example 45, more than 45 students in a class. It is very, very big issue."
			Teaching by class	Teaching organisation by subject affects teachers' ability to develop their pupils' competencies	"I think maybe a comment I can make is about the new structure of rotating teachers where every teacher has a course they teach. It has…I believe that it has a negative impact on the lower levels of classes from P1 to P3 because those pupils are still very young."
			Education reform processes	The pace and processes of educational reform should be revisited	"So also, parents should be informed about this new curriculum, also the local leaders should also be informed and trained about the new curriculum, but they are not yet."
		Enhanced delivery of teaching	Better infrastructure	Improvements in school infrastructure are needed for teachers to better nurture learners' skills	"Also about infrastructure, there will be like…we have to learn ICT but we don't have electricity in classrooms so that's bit of a challenge."
			Improved access to learning materials	The availability and procurement of appropriate learning materials such as books and computers should be improved	"Also the learning materials, they are not available on time and when they come, they are available, they are not enough relatively to the number of students, they are not sufficient."
			Increased teacher training	Teachers need further training on English and implementing the curriculum	"So the other things I would like to see, I would be happy to see are trainings specifically in the English language."
			Favourable teaching conditions	Teacher pay and workload should be reconsidered to enable them to teach more effectively	"Another thing I would like to speak to about is…we know our country is poor and such but a teacher needs a motivation, a financial motivation to be able to do their job well."