A study of the use of technology in teaching students with executive function difficulties (EFD) in the Kingdom of Saudi Arabia: Teachers' and parents' perspectives

By

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Abstract

This qualitative multiple case study explores teachers' and parents' views of the use of technology in addressing executive function difficulties (EFD) in primary schools in Saudi Arabia. Executive functioning skills (EFS) are crucial high cognitive functions that control thoughts, emotions, and actions, and determine the ability of students to adapt to different social settings in both mainstream educational and home contexts. Primary executive functions, such as cognitive flexibility (CF), working memory (WM), inhibitory control (IC), and attention are critical components of behavioural and cognitive development and have a strong association with academic performance.

The rapid rate of technological integration in special education, notably in primary schools, calls for greater understanding of the role technology can play in addressing EFD. This study draws on data collected via 21 semi-structured interviews with teachers and parents and 18 classroom observations in three primary schools in Saudi Arabia to explore how technology was employed in the classroom to support students with EFD. Thematic analysis followed by cross-case analysis was informed by theoretical perspectives by Vygotsky’s cognitive development theory and the concepts of scaffolding and the zone of proximal development.

The findings show that teachers and parents hold positive opinions about the role of technology in addressing EFD. Although there was a lack of awareness about the term ‘executive function difficulties (EFD)’ amongst both parents and teachers, they were familiar with the underlying challenges. Gaps in knowledge were also identified in relation to effective and context-specific uses of technology and interventions for students with EFD. Variability in

students' manifestation of EFD, the choice of technological affordances, and the accommodations required in mainstream classrooms are important considerations for the effective use of technology. However, the analysis identified various challenges which limit teachers' optimal use of technology and their ability to determine the relevant affordances and accommodations. In light of these findings, and from a constructivist paradigm, recommendations for teachers, for practice, and for policymakers are made to address these challenges and promote more effective use of technology to support students with EFD in Saudi schools.

The research fundamentally contributes to understanding EFD and its potential to regulate difficulties in different neurodevelopmental groups in the Saudi context. This research is the first of its kind in the Saudi context and presents meaningful implications for future research, specifically to expand the body of evidence on how EF skills may provide competencies in relation to Theory of Mind (ToM), and how technology may function as a mediating tool. The findings also raise crucial questions to be addressed in future studies to explore the underpinning mechanisms of EF-ToM association, and how use of technology can facilitate in the context of behavioural synchronisation, so as to lead to improvement in EFD using the concept of ToM. The thesis suggests potential recommendations for teachers, policymakers, and the educational ministry to address gaps in EFD. These recommendations include developing EFD-specific technological affordances, capabilities, and functions, enabling customisation of applications with EFD-specific design specifications and features, and catering to the training and development needs of teachers through teacher-oriented programs, workshops and conferences. This will enhance their knowledge base of EFD and improve the overall educational experience in the Saudi context.

Keywords: *Executive functioning skills (EFS); executive function difficulties (EFD); technological affordances; technological integration; primary education; teachers' perspectives; parental perspectives; Saudi Arabia*

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List of Abbreviations

ADHD	Attention deficit hyperactivity disorder
ASD	Autism spectrum disorder
BERA	British Educational Research Association
CF	Cognitive flexibility
EF	Executive function
EFD	Executive function difficulties
EFS	Executive functioning skills
HoD	Head of Department
IC	Inhibitory control
ICT	Information and communication technology
KSA	Kingdom of Saudi Arabia
LD	Learning difficulties
MKO	More Knowledgeable Other
MoE	Ministry of Education, Saudi Arabia
NDP	National Development Plan
NTP	National Transformation Programme
PLC	Professional learning communities
RQ	Research questions
SEN	Special educational needs
ToM	Theory of Mind
UDL	Universal design for learning
UoN	University of Nottingham
WM	Working memory
ZPD	Zone of Proximal Development

1 Chapter 1: Introduction

1.1 Chapter overview

This study adopts a qualitative multiple case study design to explore teachers' and parents' views of the use of technology in addressing executive function difficulties (EFD) in Saudi Arabian primary schools. This chapter introduces the key concepts involved, beginning by discussing executive functioning skills (EFS), then moving on to describe the study setting. It defines the research problem, provides a rationale and motivation for the study, and sets out the aims and research questions. The author's positionality in relation to the research topic is identified, and a note on the use of terminology in the study is provided. The chapter concludes by outlining the organisation of the thesis.

1.2 Executive functioning skills (EFS)

Executive functioning skills (EFS) is a broad term covering a range of high-order cognitive skills that significantly influence every individual's life and across different neurodevelopmental groups (Meltzer, 2018). Executive functioning (EF) is usually viewed as a multi-dimensional construct that is separable from, but reliant on, other ingredient skills of intelligence, visual processing, and vocabulary. The importance of these skills is linked to the fact that they play their role in various contexts throughout an individual's life, e.g., academic performance, daily routine activities, and social interaction skills (Cortés Pascuel et al., 2019). EFS provide a platform for an individual's learning, academic performance, and appropriate behavioural functioning (Meltzer, 2018). Students experiencing executive function difficulties (EFD) may exhibit inappropriate academic and social behaviours, and generally do not respond well to standard methods and ways of teaching. Hence, they require special attention and help (Motamedi et al., 2016).

Due to the importance of EF as a foundational construct in students' academic success, numerous educational researchers have investigated its various dimensions; however, studies suggest that the different constituent parts and effects of EF are confusing and contradictory (Tschida and Yerys, 2022). Moreover, there is considerably more information about EF in a home context than in an educational context (Tschida and Yerys, 2022). Several studies have shown that individuals with EF issues encounter difficulties in their day-to-day activities as pertains to planning, time management, organisation of tasks and thoughts, problem solving and attention control (Meltzer, 2018). Regarding students with special educational needs (SEN), EFD can make learning and educational development challenging because of the coexistence of other neurodevelopmental, behavioural, and intellectual difficulties (Eigsti et al., 2011; Johnson et al., 2016). Furthermore, EFD in students with SEN can also cause disruptive behaviours, making it more difficult for them to achieve goal-oriented behaviour (Leonard et al., 2015).

It is important to understand that no one is born with EF skills, but the potential to develop them exists from birth (Harvard University, 2018). In the educational context, children need to develop an increasingly complex array of EF skills (Craig et al., 2016), and research has examined various pedagogical strategies, teaching methods, and interventions for supporting the regulation of EFD in students (Cuevas et al., 2014; Bardack and Obradovi, 2019). Studies indicate that the development of EFS advances through the collaboration, interactions, and participation of children with competent peers, teachers, parents and siblings, and their contingent responses (Vygotsky, 1978b; Mermelshtine, 2017; Spruijt et al., 2019), and the importance of a collaborative environment created by parents and multiple school factors for the effective management of EFD has been highlighted (Mermelshtine, 2017). Parents and teachers play a critical role in structuring activities (Spruijt et al., 2019; Bardack and Obradović, 2019), and the teacher's role in enhancing student engagement and meeting the additional needs of students with EF in a structured school context is especially important (Sulik and Obradović, 2018). However, there is little clear guidance about “what works for whom, and under what conditions” (Marzocchi et al., 2020, p. 3).

1.2.1 Scaffolding to support EF development

In order to develop EF skills effectively, children require an appropriate level of adult support, such as developing appropriate routines, modelling of EFS and exhibition of social behaviours, and generally maintaining supportive relationships (Bardack and Obradović, 2019). These actions, typically provided by both teachers and parents to guide students through various tasks, provide the scaffolding which is imperative in enhancing EF skills (Ciullo and Dimino, 2017). Scaffolding can be defined as a process whereby a more capable adult or peer guides the learning and development of the student (Rojas-Drummond et al., 2013), helping them to execute a task that is otherwise beyond their level of proficiency/ability. The level of support changes over time, increasing when a child is struggling, and reducing when the child succeeds in executing the task on their own.

Facilitators or teachers incorporate scaffolding in different ways to highlight explicit, systematic, instructional and cognitive support to ensure that students obtain a solid foundation in a specific skill or target content learning (Vaughn et al., 2015; Ciullo and Dimino, 2017). Rosen et al. (2014) highlight the potential of scaffolding, specifically with regard to cognitive difficulties, to help students to manage their own EFD in complex tasks. In this context, instructional support, understood as the scaffold, was directed as an intervention and technology was used to help students self-regulate and monitor their behaviour (Rosen et al., 2014). Applying the scaffolding metaphor to a specialised instructional technique, Ciullo and Diminio (2017) discovered that guided practice, modelling, and teaching strategies improved outcomes in students with learning difficulties, regulatory problems, and cognitive functioning challenges. In addition, Mazursky-Horowitz et al. (2018) found that scaffolding may help children with cognitive difficulties, in this case attention deficit hyperactivity disorder (ADHD) and autism, to overcome core challenges such as inattention, disorganisation, and difficulty in self-regulation of the EF construct. Studies such as these indicate a greater need for structuring of instructions, guidance, and support for children with EFD; however, there is insufficient research examining the efficacy of teachers' scaffolding to address these EF challenges.

1.2.2 Technology leveraged scaffolding

Given the increasing adoption of technology, scholars are now exploring its use to enhance EF skills in educational contexts (Fitzpatrick et al., 2014), and teachers, facilitators, and researchers are particularly interested in the role of scaffolding in a technology-mediated classroom (Kim and Hannafin, 2011b; Axelsson et al., 2016). Although there are now well-grounded guidelines to assess the scaffolded learning of students with EFD using tools such as iPads and tablets, in both mainstream schools and inclusive educational settings, (Raes et al., 2012; Nelson and Johnson, 2016), more advanced interventions and tools have been leveraged to regulate the complex cognitive problems of children in different diagnostic groups. Studies suggest that these could be effective in enhancing EF gains in different neurodevelopmental groups (Marzocchi et al., 2020); however, technology-mediated learning needs to be explored further within educational settings (Falloon, 2017).

The increasing trend of mainstreaming and inclusion of students with learning and cognitive difficulties is opening new research avenues to determine how these developments can support children with special needs in mainstream settings. For example, Manta et al (2020) found that emerging technological tools are effective in helping to address the cognitive challenges of students with ADHD and autism in the mainstream system. Such findings suggest that technological solutions can support students in different domains of learning and cognition (Axelsson et al., 2016), including those with cognitive complications such as EFD. Existing research about the use of technological tools involving parents and teachers has also identified noticeable improvements in a variety of EFs, including significant improvements in sustained attention, IC, and self-regulatory behaviour in students with ADHD, autism and language impairments (Prins et al., 2013; van der Oord et al., 2014). Studies on training through technological tools have also identified significant amelioration regarding autism and language impairments (Vugs et al., 2017). However, while Rachanioti et al. (2018) acknowledge their potential, they also highlight other factors linked to these improvements, such as different levels of learning for each student and more effort and time needed for improvements for some students. Thus, the use of technological tools to address EFD in mainstream inclusive settings requires further investigation and analysis.

This study examines the ways in which technological tools are used in mainstream Saudi primary schools to support students with EFD, how the technology is deployed in classrooms, and the scaffolding required to facilitate students engagement with it. As the level of awareness of EFD in teachers (Long et al., 2016) and parents (Jusienė et al., 2020) is significant in relation to the appropriate use of technology and interventions (Takacs and Kassai., 2019), this research foregrounds the roles and perceptions of teachers and parents with regard to the use of technology and their understanding of the cognitive complexities associated with EFD. The study concludes by offering suggestions to enhance provision for students with EFD for teachers, future researchers, policy makers and authorities in Saudi Arabia.

1.3 Use of terminology in the study

Despite the fact that the terminology preferences regarding individuals with neurodiversity needs and cognitive challenges have been amply documented in several peer-reviewed publications and large community surveys, these preferences are frequently neglected in published research. The terminology preferences of the neurodiverse community, including those who are autistic, dyslexic, or have ADHD, must be supported and adhered to by researchers, journals and funding bodies, who must also regularly review and update their choice of language in line with the values of the relevant community. A change in how research pertaining to these differences is done should coincide with the development of the terminology used to describe them.

Identity-related concepts must navigate issues related to the discrimination and stigmatisation of individuals with special needs, and neurodiversity globally. Unfortunately, special education research and therapy have employed pejorative language. The preference for well-informed use of terminologies empowers and changes the community's views of these individuals. Vivanti (2020) acknowledges that language choice may ‘influence cultural opinions, public policy, therapeutic practice, and research directions’. The analysis of the global perspective on the use of terminologies lacks consent and revolves around person-first and identity-first approaches.: Studies conducted in English-speaking countries, e.g., Buijsman et al. (2022), have revealed a prevailing inclination towards identity-first language (e.g., 'autistic person') for individuals on the autism spectrum, as opposed to person-first language (e.g., 'person with autism'); relative to this, some are inclined towards a person-first approach. In a similar context, the American Psychological Association (APA) recommended person-first language (PFL) over identity-first language (IFL) in 2010 due to concerns about the potential degrading of individuals by subjecting them to their particular condition. However, in 2020, the APA provided modification guidance on the most suitable approach based on participant preferences.

Despite observing differences in levels of acceptance across different countries, the research by Keatings et al. (2022) revealed that the most commonly used terms were remarkably similar. The following terms were consistently preferred across all countries such as "autistic person," " is autistic," "person with neurological difference," "person with challenges and difficulties," "neurotypical people or neurotypicals”. Despite the existence of a general agreement across many groups, the analysis of both quantitative and qualitative data in the study signified that an internationally recognized approach to discussing these disabilities remains challenging. This disparity in the choice of terminologies also reflects the phenomenon of cultural preference in word choice to avoid potential harm (Buijsman et al., 2022).

It is crucial to have a comprehensive understanding of the cultural notions and beliefs surrounding disability within the Saudi cultural setting. This understanding is essential in order to appropriately examine the preferred terminologies for the various diagnostic categories indicated in the present study, primarily autism, ADHD, and dyslexia. It is important to align these preferences with the values and preferences of the community. According to a recent report published by Arab News, it has been mandated that Saudi government agencies utilise the term "persons with disabilities" in the official documentations and media reports and statements. The aforementioned decision was undertaken as a response to the use of varied terminologies in reference to individuals with disabilities on different communication media platforms (such as committee reports presented at United Nations Human Rights Office of High Commissioners OHCHR in 2019) and to avoid confusion with non-Arabic speakers at international forums. This directive was further recommended by Ahmed Al-Rajhi, the Minister and Chairman for Care of person with disabilities in KSA (Arab News, 2019). Hence, the utilization of the term "persons with disabilities" is an essential aspect of Saudi Arabia's adherence to international standards and represents a generally accepted terminology. However, in a research context, Madi et al. (2019) contrast with this view and mention official association recommendations to avoid using the term ‘disability’ as a protective measure for individuals and their families. Alternatively, the phrase ‘individuals with special needs’ should be employed (Madi et al., 2019).

Therefore, keeping in view the above mentioned disparities around different contexts and the preference to use identity first language, I have used the terms ‘students *with* autism, dyslexia or ADHD’. This is to describe students with EFD aligning with person first language approach as the proponent of ‘people first’ language in the Saudi Arabian context, according to which reference to the person should be situated before perceived difficulties and challenges. Moreover, the term ‘Student with Executive Function difficulties’ would appear to achieve consistency with the terminological implications of both people first and social model approaches (Lawson and Beckett, 2021).

1.4 Study setting: Saudi Arabia

Saudi Arabia’s current national development plan, known as "Vision 2030", includes several initiatives that aim to transform traditional learning into modern education practices characterised by digital technology (MoE, 2018). As a consequence, schools in Saudi Arabia are being encouraged to make much greater use of technology, i.e., shifting to digital education to support teacher and student progress, including for students with learning, intellectual, and behavioural challenges (OECD, 2020). These proposals further direct teachers to establish a practical framework and develop the structure of an optimised digital classroom by introducing personalised learning programmes using digital devices to address students' individual needs. The Future Gate programme, initiated by the Ministry of Education (MoE) in 2017, introduced the notion of "changing the whole school setting” and distributed iPads to students and teachers to further strengthen technological accommodation in the educational setting (Al-Sughair, 2015). The initiative also targets the activation of digitalised learning as a national learning strategy (PSBAU, 2018), and different versions of technologies, namely, high, medium, and low categories (See Appendix 1), have been adopted to help students with diverse learning needs engage in inclusive learning (Aldabas, 2015).

The most common learning and developmental difficulties in KSA include visual impairment, hearing impairment, intellectual disability, autism, and multiple disabilities (Aldabas, 2015; Almani, 2017). Since the 1970s, developmental reforms and investments have been implemented in both mainstream and segregated educational contexts in Saudi Arabia, including special education services. These have included optimising facilities for children with learning difficulties to benefit from initiatives executed by the government and its ministries (Abu-Alghayth et al., 2022). In response to the increasing percentage of SEN students enrolled in its 27,000 institutes, the MoE has started improving developmental programmes, particularly in inclusive settings (Almani, 2017). These efforts have largely focused on enabling students with SEN to develop essential skills and progress academically in a general education setting (Aldabas, 2015; Alresheed et al., 2017). Investment by the Saudi Government to address the learning and educational needs of students with autism and dyslexia, as well as those with ADHD, has included efforts to integrate newer technologies into this area (MoE, 2012).

However, despite the government's efforts, research suggests that certain cultural barriers make accepting and integrating technology into education in the Kingdom difficult (Alresheed et al., 2017). There is a need for further studies to assess the pace of adoption of technology (Aldabas, 2015), and, in the context of this study, the readiness of teachers and parents to adopt technological solutions to improve EF skills (Alresheed et al., 2017; Calcagni and Lago, 2018). For example, although mainstream teachers stress the importance of determining how parents perceive the role of technology in improving their children's EF skills (Alotaibi and Almaliki, 2016), studies have indicated that some SEN teachers in Saudi Arabia are hesitant to work with parents, claiming they are not interested in discussing their children's improvement and technological interaction with them (Dubis and Bernadowski, 2015). Meanwhile, Al-Gharaibeh (2012) found that some Saudi parents' failure to understand the role and significance of using technology undermined their children's collaboration and interaction with technological solutions. This gap in assessing the teacher's and the parents' perceptions of the use of technology to address the EF difficulties of the child is fundamental, and is one of the key reasons why this study explores both parents' and teachers' perceptions of using technology to address the learning needs of students with EFD in Saudi Arabia.

1.5 Statement of the problem

Cases of students with autism, ADHD, and dyslexia struggling with major cognitive difficulties are increasing. If left unaddressed, these difficulties are likely to increase (Manta et al., 2020), manifesting in behaviours that are challenging for parents and teachers (Berenguer et al., 2018), and negatively impacting students throughout their lives (Sefotho and Onyishi, 2021). The increasing use of technology in education provides new ways to address students' learning needs (Qureshi et al., 2021), and research indicates that appropriate technological tools can enhance cognitive process and support students with EFD (Marzocchi et al., 2020). However, teachers' attitudes, perceptions, experience, and expertise affect the technology's overall contribution to tackling students' EF challenges (Liu et al., 2016), and the active support of parents is also essential (Mermelshtine, 2017).

The Kingdom of Saudi Arabia is now seeking to digitalise its education system, and a range of new technologies have been adopted to help students with diverse learning needs engage in inclusive learning (Aldabas, 2015). Although there is acknowledgement of the effectiveness and importance of such technologies for students with EFD in other contexts (Israel et al., 2015), little is known about the instructional use of digital devices with students in Saudi classrooms and the scaffolding measures required. While evidence suggests that teachers and parents appreciate the use of technological innovations and tools in Saudi schools (Alnahdi, 2014; Alsolmi, 2017), there is no existing research to inform the development of effective strategies for their use with students with EFD, and limited understanding of teachers' and parents' ability to support these students, especially in inclusive classrooms.

1.6 Rationale and motivation for the research

The study is driven by the need to address the learning needs of students with EFD and to explore the specific strategies and techniques adopted by teachers for the use of technology to impact EF. This focus is justified by the existing literature, which reveals that there are gaps and underreported domains regarding executive function difficulties. Although executive functioning has been recognised as a fundamental cognitive process for more than 20 years (Garon et al., 2014), as Blair (2016) notes, much is yet to be learned about it, and there remains a significant lack of evidence in different contexts. While many studies have assessed the development of EF and the potential of various training programmes, research to determine the role technology can play in addressing EFD in mainstream classroom situations is scarce, and, to the best of the researcher's knowledge, no previous studies have examined this topic within Saudi educational settings.

There is also an increasing interest in identifying the role of educators and professionals from various domains, including special education, in executing technologies intended to manage and address cognitive, emotional, and behavioural difficulties or, more precisely, executive functions (Macdonald et al., 2018). As technology plays an ever greater role in education, the availability of cognitive orthoses and training tools to improve learning difficulties and other underlying issues of students is increasing (Al-Zoubi, 2016), and, while Saudi teachers and parents appear to be optimistic about the use of technology in the classroom, there is a lack of research identifying teachers' levels of knowledge, and their ability to address the learning needs of students with EFD within inclusive educational settings.

The increase of inclusion in mainstream education in Saudi Arabia (Abu-Alghayth et al., 2022) underlines the need to evaluate the effectiveness of approaches to improve inclusive classroom design skills utilising technology, and provides further motivation for the present study. Previous literature has acknowledged the positive impact of the implementation of inclusion (Al-Natour et al., 2015), highlighting the potential it holds in valuing diversity and accommodating students' learning differences in regular classroom settings (Knight et al., 2022). In the Saudi context, Alshenaifi (2018) identifies positive attitudes among teachers towards inclusion for students with mild to moderate cognitive and learning difficulties, indicating a willingness to identify and implement necessary accommodations to be implemented in mainstream classrooms. However, it is important to explore how technology may work with students who may exhibit challenging behaviours (e.g., in relation to staying on task, or shifting between different elements of the task) in enabling their participation in learning and educational activities. This is especially true in Saudi Arabia, where, despite the government's efforts, research suggests that cultural barriers to the use of technology with these students persist in the minds of both parents and teachers.

As a result, this study examines the views of teachers and parents on the role of technology in addressing EFD in students with different neurodevelopmental difficulties. To the best of the researcher's knowledge, it is the first of its kind in the Saudi Arabian context, and it includes three case study schools, with different classes in each school selected for observation. While there is a general understanding of the complexities and issues linked to EF in the literature, exploring the use of different technological features in addressing this complex set of challenges in certain neurodevelopmental groups is unprecedented. Examining this in the primary context, with students ranging from eight to 11 years of age, is particularly valuable, as the early years have been recognised as a crucial period in EFS development (Howard et al., 2015).

It also provides an important learning opportunity. Teachers' knowledge and experience with EFD determines their conscious awareness of these difficulties, and their potential to help students develop these key skills. The role of parents is also important in developing EF skills, and parental engagement and involvement has been shown to play a key role in overall academic success (Wilson et al., 2018). Hence, the present study investigates the awareness and knowledge of EFD among teachers and parents, and their perceptions of the use of technology, and its affordances and accommodation.

Teachers are already struggling to address the complex behavioural and cognitive challenges of students with EFD, including improving their self-regulatory behaviour, staying on task, organising and planning their routine activities, and flexibility to switch between tasks and classroom activities (Dunlap, 2020). This study aims to take the use of technology to develop EFS in different diagnostic groups, and examine how it can further contribute to these students' overall learning. In summary, the current study aims to assess teachers' and parents' views on the role of technology as a modern way to support students with EFD in the current Saudi academic setting.

Although some studies have discussed the integration of technology in the Saudi context and highlighted the use of technological tools and techniques to enhance learning (Alfaraj and Kuyini, 2014), there is a lack of research linking technology directly with the development of EF skills. Given the drive towards implementing technology in educational settings and the expansion of inclusive education in the country, there is an urgent need to examine the role technology can play in supporting students with EFD and the scaffolding teachers and parents need to provide to enable these students to thrive in mainstream classrooms.

1.7 Aims and key research questions

The aim underlying the present research is to develop an insight into how technology can be used to address EFD in KSA from teachers' and parents' perspectives. Primarily, it aims to assess the use of technology in a mainstream setting, among different diagnostic groups of students, including those with autism, ADHD and dyslexia, in order to assess the variation of EFD in each group. It also seeks to understand teachers' and parents' perspectives, with regard to their awareness of EFD and how they believe technology could help to address the complex difficulties associated with it. The study also examines the strategies and techniques teachers use to incorporate this technology into their classrooms and how these could be improved to enhance students' learning. Ultimately, the study seeks to update educational professionals, school authorities and other relevant educational leaderships authorities (policy and decision makers), as well as researchers in this field.

The following research questions will be addressed to accomplish these aims:

1. *To what extent are parents and teachers aware of the concept of executive function difficulties (EFD) in Saudi schools?*
2. *How is technology being used to support students with EFD in Saudi schools?*

3. *What are the main contributions that parents and teachers see technology making to the learning of students with EFD?*

1.8 Researcher's positionality

The focus of the current research is linked to my positionality. In 2000, after graduating in Special Education from King Saud University in Riyadh, Saudi Arabia, I pursued a career as a learning disability teacher at an integrated school. I worked in the school for more than eight years, then secured promotion as a supervisor in the Directorate of Education in Afif city, rising to the position of Head of the Special Education Department (HoD) from 2008 to 2015 (when I moved to the UK for postgraduate study). Throughout my tenure as HoD, my role was to guide and monitor special education teachers from different schools in the city. In 2017, I completed an MA in Special and Inclusive Education at the University of Nottingham. In addition, I gained experience in teaching students struggling with behavioural and complex cognitive interactive components (i.e., EFD), which were impacting their overall learning and academic performance. As a result, I was motivated to develop my professional profile by becoming a Master Trainer in various training courses for special education teachers.

As an experienced education professional working with students impacted by challenges such as autism, ADHD and dyslexia, I have frequently observed challenging behaviour, emotional outbursts, non-compliance with rules, inability to keep track of learning, lack of focus and disorganised attitudes in these students. These complex issues are a manifestation of cognitive difficulties and demonstrate a lack of the required skills, which in turn impedes their academic success. In some situations, students have become overwhelmed by their diverse needs and difficulties, and it has become impossible for the classroom teacher to manage their challenging behaviour and difficulties without specialist support.

In the current scenario in Saudi Arabia, where authorities are constantly introducing educational and technological reforms, teachers need to be flexible, responsive and properly equipped to support such students within an inclusive setting (Alkhalidi, 2014). Being a professional teacher involves both distinguishing complex behaviours and understanding how to teach the EF skills that an increasing number of students needs. Hence, my experience with many cognitively limited students has inspired me to explore how modern learning alternatives, particularly technological tools, can – I hope - be used to support students with EFD in mainstream classroom settings.

In sum, I am undertaking this research with a positive inclination to assist both teachers and parents to develop effective technology-based solutions to address EFD in different contexts. The previous literature on educational reforms in Saudi special education and technological integration has motivated me professionally to examine the status quo regarding the use of technology for students with EFD and to harness this knowledge to be a more effective teacher myself and to help my peers. I also believe that it is my duty as a citizen to support the development of education in KSA by identifying gaps regarding this issue in the country, considering their implications and recommending effective solutions. On a personal level, I intend to further develop my professional practice, knowledge, and skills by working as an educational consultant in the Saudi educational context.

1.9 Organisation of the thesis

This research uses a qualitative multiple case study design to evaluate the role of technology in addressing EFD from the perspectives of teachers and parents. The study is divided into six chapters as follows:

Chapter One provides an introduction to executive function difficulties, the problem statement, and the relevant research question to be addressed in the

Saudi Arabian context. Chapter Two features a detailed literature review and reflects on critical dimensions of the study topic.

Chapter Three explains the study's methodology, including data collection techniques. Information about teachers' and parents' perspectives on using technology to address EFD was collected using semi-structured interviews and observation, to develop an understanding of the three schools' use of technological devices for students with EFD. The intent of using observation along with semi-structured interviews relates to the epistemological stance of the research, i.e., the social constructivist paradigm. It further explains the proposed analysis strategies of collected data, namely thematic analysis.

Chapter Four presents the findings and analysis of the results from all three schools. Chapter Five discusses the findings in light of the literature review. Chapter Six concludes the study by presenting a summary of the key findings, the limitations of the study and the implications of these findings for practice, teachers, policymakers and future research.

1.10 Conclusion

The chapter has introduced the research topic and described the study setting, explaining the key role technology is now playing in the Saudi education system. It has identified the research problem, provided a rationale for the research, and set out the study's aims and key research questions. It has also explained the author's positionality and the organisation of the thesis. The next chapter provides a review of the literature which is relevant to this study.

2 Chapter 2: Literature Review

2.1 Chapter overview

A critical literature review was conducted to survey the field, highlight known issues, identify the gaps that require further investigation, and establish the research questions. This chapter provides a review of five key areas in relation to the research topic and then identifies the theoretical perspective adopted for this study. It begins by reviewing technological initiatives in KSA and the different types of technological innovation in the country. It goes on to explore the literature relating to EF in detail, identifying the core EF skill areas, how EFD is manifested in neurodevelopmental and acquired disorders, and the effect this has on students' academic development. The chapter then examines the role teachers and parents play in addressing EFD and explores the effectiveness of existing school-based interventions and support strategies, with a focus on the use of scaffolding as an instructional strategy in the classroom. Thereafter, analysis of the role of technology in addressing EFD is provided, and the contributing factors and challenges in effectively executing technology-based instructions to develop EF skills in students are discussed. The chapter concludes by introducing the study's theoretical foundation, Vygotsky's Social Development Theory, reinforcing the notion of scaffolding and the Zone of Proximal Development (ZPD), which provides a construct for how students develop skills and knowledge through scaffolding, modelling, coaching and situated learning. This theoretical lens facilitates the examination of EF skills development, considering scaffolding as an instructional strategy mediated by technology.

2.2 Technology initiatives in Saudi Arabia

As explained in Chapter 1, the Saudi MoE has executed a number of initiatives to improve student learning and educational outcomes by integrating information and communication technology (ICT) into the curriculum and educational processes. Key policy reforms to incorporate digital and technological developments were introduced in the period between 1990 – 2014 as part of the 5th - 9th Saudi National Development Plans (NDP), and the MoE has inaugurated a country-wide development project called "Tatweer", which was launched in 2007 and is due to finish this year (2023). The main goal of this project is to strengthen technological integration and educational reforms, to implement new learning technologies and curricula in classrooms, to enhance teachers’ skills through professional development, and improve school facilities and infrastructure (Al-Shibani, 2015). Following the launch of this project, the 10th Saudi NDP (2015-2019) also stressed the need to upgrade teachers' and students' skills in ICT and to further integrate technology into the Saudi education system (Alharbi and Sandhu, 2018).

In keeping with the initiatives mentioned above, Saudi Vision 2030 also promotes the notion of technology integration in order to improve education, including special education, across the country (Saudi Vision 2030, 2016). Technology is now recognised as a crucial agent in supporting change in the Saudi school system, amid continuous educational reform programmes and process modifications (Lee et al, 2006; Lee et al, 2010), with the aim of "improving the recruitment, training, and development of teachers, the learning environment to stimulate creativity and innovation, and improving curricula and teaching methods" (National Transformation Programme (NTP) for Vision 2030, 2016, p. 7).

In particular, the "Future Gate" programme aspires to identify new paradigms for technological initiatives in Saudi education (Alsaleh, 2019) and to address the obstacles limiting the successful execution of such initiatives. This involves improving the use of technology, enhancing practical training and development for teachers, expanding the availability of technological devices, and providing software and high-speed internet connections to facilitate the use and adoption of technology in classrooms (Al Ohali et al., 2018). However, despite these efforts to support technological integration, studies have reported a gap in the practical education context (Al Ohali et al., 2018), notably in special education, where the use of technology has yet to meet expected levels (Fakrudeen et al., 2017).

Critical determinants of the success of technological incorporation include teachers' professional experience and technological expertise, administrative support, assistive hardware and software availability, pedagogical issues and teaching style; however, as Almadhour (2010) notes, "Unfortunately, although the Saudi Arabian government has potentially invested in various programmes, there is no clear strategic framework towards equipping technology in schools" (p. 62). Another challenge, identified by Albugami and Ahmed (2015), relates to the relationship between the MoE and school authorities. While school authorities' provision and support for integration is cited as a success in executing technological initiatives in KSA, the MoE's failure to meet their demands has resulted in a lack of required provisions. This apparent disparity between policy and practical execution suggests that coordination between ministries and school authorities, including special education authorities, still needs to be strengthened, echoing earlier findings by Robertson and Al-Zahrani (2012).

Teachers also play a vital role in making the use and integration of technology more effective because, as Allmnakrah and Evers (2020) observe, technology does not teach, teachers do. However, as technological integration requires changes at different levels, teachers need to be flexible and able to adapt to new strategies to contribute to the overall learning process (Al-shibani, 2015). Several researchers have stated that technological adoption is significantly affected by teachers' attitudes toward its use (Beacham and McIntosh, 2014), their beliefs about its effectiveness (Binyamin et al., 2017) and their training-led expertise Okolo and Diedrich (2014). In this respect, Nguyen et al. (2014) emphasise the role played by teachers' development and learning in technological integration, and the importance of training for implementing curriculum reform, new teaching strategies and innovative educational technologies has also been highlighted (Agharuwhe and Nikechi, 2009). Changes to teachers’ pedagogical schedules, and technological coaching and training through digital mentors is also crucial (Cowan and Earls, 2016).

There was recognition of the need to develop teachers’ digital competency within the Tatweer project brief, and the project plan included an outline technology competency framework, focusing on building digital skills to enable teachers to employ digital tools in their teaching and learning practices. However, Allmnakrah and Evers (2020) found that in-service teachers lacked understanding of the new educational changes associated with the Tatweer project, and there was a lack of training in the curriculum and pedagogical approaches it promotes. Al-Shibani (2015) also identified insufficient training for teachers as a limiting factor in the implementation of the project, and this indicates that lack of awareness and appropriate training remains a significant issue in the adoption of technological tools in Saudi schools. The following section considers the types of technology Saudi teachers are now expected to use in their classrooms.

2.3 Types of technological innovation in Saudi Arabia

The use of technology in Saudi classrooms has developed significantly in recent years. For instance, Al-Maini (2011) identified a lack of classroom computers and other technological tools in subject teaching; however, just a year later, Isman et al. (2012) reported that teachers were using a range of different technologies, ranging from low-tech to high-tech assistive devices, such as interactive whiteboards, tablets/iPads, mobile devices, computers and LCD projectors to enhance the learning process. Projectors in particular may help to bring real-life situations to the classroom by displaying movies, videos and animated stories. They also enable teachers to develop lessons using free online materials in selected apps, and most schools in KSA now have computer labs for students and teachers to use.

Several studies have explored specific technology-based practices of teachers in elementary and intermediate schools in Saudi Arabia. For example, Bakadam and Asiri (2012) mention the use of interactive whiteboards as overhead projectors to present learning content to students on PowerPoint, and Al-Faleh (2012) reports that tablets and iPads were used with various applications to enhance and support the learning process. Alhawiti (2013) reported the wide-spread use of digital projectors, internet-connected computers, and interactive whiteboards, and a study by Alfaraj and Kuyini (2014) also identifies computers, iPads, and projectors as being most frequently used in the classroom. More recently, Anbalagan (2022) reported that interactive whiteboards, otherwise known as smartboards, were usually connected to a computer or laptop to interact with internet applications.

2.4 Support for students with SEN in Saudi Arabia

Special education in Saudi Arabia has made significant progress in assisting students with learning, developmental, cognitive and behavioural difficulties to obtain an education (Aldabas, 2015), and the MoE has directed considerable effort to fulfilling these students' educational and learning needs through essential provisions and support facilities (Battal, 2016). Special education classrooms have been facilitated in mainstream public schools to educate students with visual and hearing impairments, deafness, cognitive and intellectual disabilities, and autism, and the proportion of such students is rising each year (Almani, 2017).

The increasing prevalence of different developmental and cognitive difficulties in Saudi schools signifies the need to develop research based on these areas, and the concept of EF is of critical importance in trying to understand a myriad of learning difficulties (Meltzer, 2018). However, a detailed search of previous studies has identified no study on EFD in the Saudi context, despite its significance in relation to autism, dyslexia and ADHD. As a result, much of the rest of this chapter explores EFD in detail, considering EF in relation to academic development, the part teachers and parents play in addressing EFD, the different types of school and classroom-based interventions adopted, the role of technology in respect of supporting students with EFD, and parents' and teachers' perspectives on its use in this way.

2.5 Executive functions (EFs)

Internationally, there has been substantial research about executive functions (Zelazo and Carlson, 2020), and EF was recognised as the chief executive officer of the brain two decades ago (Granpeesheh et al., 2014). However, EF has been an unclear construct historically, and different researchers have offered wide-ranging definitions for its underlying characteristics (Griffin and Freund, 2016). While most identify broad and diverse processes regarding various forms of self-regulation, sustained attention, and planning as core components of EF (Meltzer, 2018), no single definition is universally accepted (Zelzao et al., 2016).

Although EF lacks a shared set of conceptualisations and definitions, the broad concept of EF is a unitary functional or single-dimensional construct (Lerner and Lonigan, 2014). Researchers have commonly, but not consistently, depicted EF as a specific set of attention-regulation skills involved in conscious goal-directed problem-solving (Zelazo et al., 2016). However, more recent research considers EF as a combination of several processes, involving a specific set of constructs (Schoemaker et al., 2014; Meltzer, 2018). Naglieri and Goldstein (2013) define EF as an individual's efficiency in solving their problems effectively in nine different domains, namely: planning, organisation, focus/attention, inhibitory control (IC), task initiation, working memory (WM), self-regulation and monitoring, emotional regulation, and cognitive flexibility (CF). Within this context, WM refers to the tendency of an individual to hold, manipulate, and retain information in their mind; CF refers to the ability to adapt behaviour and responses to changing contextual requirements; and IC refers to limiting or controlling impulsive responses or reactions, and giving responses using attention and reasoning. These key constructs of EF are discussed in greater detail below (See 2.6).

Based on its potential impact, the concept of EF has received significant attention from researchers over the last fifty years (Goldstein et al., 2014). Although the term 'control mechanism' was once used interchangeably with EF (Pribram, 1973), along with a number of others (Shifrin and Schneider, 1977; Baddeley and Wilson, 1988; Posner et al., 2004), EF is now primarily defined as the central system for planning, organising, and completing tasks within given deadlines (Sulik et al., 2015; CTD, 2018). This encompasses a self-directed set of actions that reflect the capacity to control and regulate behaviour to achieve goals (Sulik et al., 2015). While Delis (2012) views EF as a collection of high-order skills that enable the functioning of individuals in complex psychosocial contexts, and argues that the conceptual scope of some definitions neglected the broader aspects of EF, later studies, notably as Meltzer (2018) identify EF skills as "a domain of neurocognitive competence" (p. 6), and describe them as functions that control the range of cognitive skills that regulate an individual's attention, needed for learning and academic growth, as well as regulating the behaviour needed for required performance (Bardack and Obradović, 2019).

The concept of ‘EF functions’ is also used as an umbrella term to refer to cognitive processes associated with early academic accomplishments (Goldstein et al., 2014), and there is general agreement that EF contributes to a child's academic profile and plays a vital role in their social and behavioural development, self-regulation and WM (Dawson and Guare, 2018).

EFs help to regulate thoughts and behaviour (Cartwright, 2012), and they can direct students' behaviours in an organised, planned and goal-directed way (Ellis Weismer et al., 2018). Hence, EF skills are foundational to developing the cognitive and social capacities crucial for social well-being and academic readiness (Keown et al., 2020). They also have a developmental relationship with other cognitive skills during preschool and early educational years (Ackerman and Friedman-Krauss, 2017). Collectively rendered as EF, these higher-order abilities are typically manifest in the early years of life (Lepach et al., 2015) and have a significant influence on school readiness and overall academic success (Jacob and Parkinson, 2015; Mann et al., 2017; Vandenbroucke et al., 2017). The mainstream classroom setting therefore presents considerable challenges to students with EF difficulties, as academic progress and transitions require sustained attention, and effective WM and other cognitive functions (Heyl and Hintermair, 2015).

Impairments in EF skills (known as EFD) have the potential to impact both students' academic progress and their interactional, social, emotional and adaptive functioning in early and later life (Meltzer, 2018). These difficulties may initially manifest in infants and preschool children as either a unitary or multi-dimensional construct, indicating that many components or processes - that may be interrelated or independent – are involved (Miller et al., 2012). The challenges associated with EFD impact a student's ability to access, organise and coordinate activities simultaneously, affecting their learning tendencies in all areas, including reading and writing, making them "actively inefficient students" (Meltzer, 2007 p. 79). EFD co-occurs in different behaviourally diagnosed groups, such as ADHD, and with neurodevelopmental groups, including autism spectrum disorder (ASD) and dyslexia (Bathelt et al., 2018); however, individuals typically struggle with self-regulation, such as checking, monitoring and revising during their different learning tasks. The considerable heterogeneity of EF domains has significant implications for devising effective strategies and interventions for educational authorities, in both general and specific education contexts (Otero et al., 2014).

Given the multiple cognitive processes involved, developing EF skills in the individual learner is a complex and prolonged process (Meltzer, 2018). Different aspects of EF are exhibited at different ages, and appear to change throughout a child's development (Best et al., 2009). Some aspects are apparent from birth (Juric et al., 2013) and some are manifested in later childhood, with the three core elements, IC, WM and CF, typically exhibited from early infancy (Allom et al., 2016), with considerable development in WM, shifting and planning, occurring after the age of five (Best et al., 2009). Similarly, Zelazo et al. (2016) found that manifested EF skills begin to develop shortly after birth and evolved through early childhood, noticeably between the ages of two and eight. Some aspects of EF increase in early adulthood; for instance, cognitive performance peaks in young adulthood, while the rate of IC development is steepest in childhood but continues to improve in adulthood (Ferguson et al., 2020). However, the period of preschool and early elementary schooling is a key developmental phase for EF (Howard et al., 2015) and a crucial time to help children develop these skills.

Potocki et al. (2017) suggest that some EF functions mature earlier and more rapidly when development is subjected to early intervention (Nilsen et al., 2018). However, as Keenan et al. (2019) explain, the coexistence of other disorders can lead to different trajectories of EF development, as EFD may further compromise an already impacted cognitive system, affecting both behavioural and emotional regulation (Alsaedi et al., 2020). For example, the exhibition of poor IC reflects ADHD and poor CF characterises ASD (Ellis

Weismer et al., 2018). It is therefore important that EFDs are considered from a young age in order to implement treatments at the time when they might be most effective (Chaimaha et al., 2017). It is also essential to comprehend the complexity and diversity of EF, and to explore how this varies across different diagnostic groups in order to determine further interventions and approaches. As a result, the following section examines the core EF skills which are most relevant to this study.

2.6 Core areas of executive functioning skills (EFS)

Most scholars agree upon three core EF areas (IC, WM and CF), which are separate but interrelated, and which contribute distinctively to various tasks (Meltzer and Dunstan-Brown, 2018). However, researchers have traditionally viewed EF through the cognitive lens, offering theories, paradigms and assessments of EF integrated cognitive skills (in abstract and non-emotional situations/contexts) only and neglecting the role of motivation and emotions in the development of EF (Welsh and Peterson, 2014). More recently, Zelazo and Carlson (2020) have addressed this gap by proposing that EF develops and varies due to the motivational implications of a given situation. Another distinction within EF is between "hot" and "cool" EF, where the former relates to EF skills exhibited in a personally meaningful situation, where there is a motivation to solve a problem, and the latter type, is more abstract and exhibited in non-affective situations (Zelazo and Carlson, 2020). In this context of this study, Tsermentseli and Poland (2016) contend that the motivational and affective aspects of EF (hot EF) pertain to those emotional and social situations that significantly relate to students' school readiness, academic performance, and behavioural patterns.

There is a broad consensus that IC, WM, and CF constitute the EF skills that most significantly direct an individual's behaviour towards required goals (Diamond, 2013). These skills further constitute the foundation for higher-order EF skills, such as planning, organising and problem solving, that are required to resist impulses and remain goal-directed (Diamond, 2012). Hence, the development of these core skills is critical. The difficulties resulting from poor EFS hamper students' ability to maintain other skills necessary for learning and academic growth. Hence, the present study assesses the variation in EFD exhibited by students with different developmental challenges from parents and teachers' perspectives. The study further determines their perceptions regarding provision of classroom opportunities for students to practice core EFS through use of technology. The three core components of EF are detailed in the following sections.

2.6.1 Inhibitory control (IC)

IC is an early construct of EF which develops quickly, particularly between three and six years of age, and is a key aspect of individual development (Bruchhage et al., 2021). Known as the individual's self-control, impulsivity or behavioural inhibition tendency (Freeman et al., 2017), it also regulates the control of thoughts, hampering actions - including motor, verbal and non-verbal behaviour - that determine the self-disciplining tendencies of an individual (Diamond, 2013). There is a prevalence of IC deficits in certain neurodevelopmental disorders, such as ASD (Schmitt et al., 2017), manifesting from as early as 24 months (Bruchhage et al., 2020).

Efforts to improve IC, typically focus on developing the academic and social competence of the student (Meltzer, 2018), and several studies have observed that providing significant instructional support (reciprocal child-teacher interaction) can be effective (Choi et al., 2017). In their longitudinal study, Son et al. (2019) also identify a reciprocal relationship between IC and different academic skills, such as maths and numeracy skills. In the context of addressing IC in ADHD students, Meyer et al. (2020) suggest that enhancing IC alone has the potential to address different behavioural and cognitive challenges in these individuals. Several other studies have reported that the early provision of intervention and effective teacher-student interaction, including emotional support and well-organised classroom structures, can significantly improve IC; however, these depend on the school and classroom environment as an important developmental context for promoting EF skills, specifically self-regulation and IC, and the quality of teacher-student interaction (Sankalaite et al., 2021).

Technology-based IC training has been found to be both intriguing and challenging for young adolescent students with EFD (Wells et al., 2021), and Brucchage et al. (2020) report improvements in IC skills in children with EFD, aged from 2 to 6, via tablet-based EF tasks. In their study, a score for each participant's successful inhibition was computed from the number of balls avoided, corrected for their attentiveness and interaction with the assessment. The findings indicate that increasing the complexity of technology-mediated tasks can ensure improvement in the self-regulation and IC of such students, and suggest that technology-mediated tasks can engage students to complete them more effectively.

These studies indicate that both teacher-student and technology-mediated interactions to improve IC in these students can be effective. However, there remains a need to explore and assess further ways to provide opportunities for students with EFD to practice inhibitory control skills, to stay on task, and to control emotions, both independently and with small groups of peers, in a mainstream setting.

2.6.2 Working memory (WM)

WM permits an individual to have and (re)produce information in their mind (Diamond, 2013). Like IC, it develops rapidly during early childhood (Fitamen et al., 2019) and determines a child's ability to retain and process information. During preschool, WM relates significantly to school readiness and children's developing numeracy skills (Gomez et al., 2018; Cragg et al., 2017). WM may be verbal or non-verbal (Diamond, 2013). It is distinguished based on content and is fundamental to developing linguistics (spoken language), writing, numerical skills, sequencing and scheduling items, considering instructions and taking actions, and developing connections between different points of information and ideas (Dias and Seabra, 2017). Thus, it controls the role of keeping and manipulating information in mind.

According to Zelazo and Carlson (2020), WM enables the development of more engaged, active and reflective learning and reasoning in students, all of which require adequate WM for their typical manifestation. Thus, interventions and strategies to enhance WM are also effective in improving related issues (for example, attention and focus). Preliminary findings on WM training and improvement indicate that non-trained EF measures were also enhanced (Goldin et al., 2014). For example, Bardack and Obradović (2019) found that WM training using scaffolding instructions provided by the tutor also encouraged students to develop problem-solving tendencies. Equally, Goldin et al. (2014) demonstrated that training 6 to 7 year-olds through 20 - 25 sessions focusing on WM and IC also enhanced non-trained variables, such as CF, language and numeracy skills. The same study also proposes that computerised games might yield transfer of some EF skills to real-world measures of school performance.

2.6.3 Cognitive flexibility (CF)

The third core EF function, cognitive flexibility, pertains to the flexibility of mental abilities. Blakey et al. (2015) characterise this as a complex construct, which is facilitated by improvements in IC and WM (Chevalier et al., 2012). CF includes changing and shifting from one idea to another, developing and changing perceptions about something, or being able to think beyond the typical thinking reference (Zelazo et al., 2016). In the case of solving a mathematical task, for example, cognitive inflexibility interferes with the student's ability to problem-solve, generate ideas, see differing perspectives, or think critically to complete a task. Unfinished activities or omitted issues and an inability to follow instructions underline the absence of CF (Irwin et al. 2019), and Meltzer (2018) proposes that students' challenges in this domain often become more apparent to teachers during group activities.

The onset of CF is generally recognised to begin in early childhood and continue until late adulthood. Ferguson et al. (2021), for example, posit that it emerges between the ages of 3 and 4, develops in a more complex process between the ages of 7 and 9, and reaches adult-like levels by age 12. However, Zelazo et al. (2014) hold that CF abilities continue to develop between the ages of 20 and 29, underlining the importance of executing different approaches and tasks to assess EF abilities.

These sections have discussed the importance of assessing the interconnected nature and interdependency of all three core EF functions (WM, CF and IC), how they work together to develop the sub-skills included in EF, and how variations within them result in different manifestations. Table 2-1 below illustrates the core EF characteristics and their manifestations. Understanding these core features, as well as the difficulties associated with EF, helps to examine how these features are manifested by students in the Saudi setting of this study. Furthermore, there is a value in determining how these complexities vary across different diagnostic groups. Therefore, the following section provides critical analysis of EF in neurodevelopmental and acquired disorders, examining in particular how different EFDs are manifest in certain neurodevelopmental groups, as this is a key issue within this research study.

Table 2-1: Core features of EF skills and manifestations (Behaviour Rating Inventory of Executive Function [BRIEF]; Gioia et al, 2000) adapted from Greenstone (2011, p. 102-104).

Executive function domains	***Features***	***Manifestation of difficulties***
IC	Ability to control impulses and inappropriate behaviour	• Impulsivity often exhibited before listening to instructions • Requires constant supervision and assistance to remain on task and focused • Distracting and interrupting progress of others
WM	Ability to retain information and actively use or manipulate it to complete a task	• Trouble memorising, especially instructions • Losing track and purpose of their actions • Lack of sustained attention
CF	Ability to change attention, manage transitions and tolerate flexibly, shift focus	• Difficulty in transition of tasks and activity • Difficulty tolerating change (for example a change in a planned activity)
Planning/ Organisation/ Time management	Ability to set goals and complete a task, organise information	• Inability to estimate time for a task • Inability to keep track of homework assignments
Self-monitoring/ Regulation	Monitoring accuracy, time management, effectiveness of strategies	• Inability to assess their performance after task completion • Difficulty determining the effect their behaviours have on others

2.7 Executive function in neurodevelopmental and acquired disorders

A large body of evidence indicates that EFD is common in children with neurodevelopmental disorders (Demetrious et al., 2018). These difficulties are exhibited irrespective of age, gender, or functional tendencies (Meltzer, 2018) in different diagnostic groups, including ASD (Jhonston et al., 2019; Filipe et al., 2020), dyslexia (Lonergan et al., 2019), ADHD (Crisci et al., 2021) and other intellectual disabilities (Kapa et al., 2017), with each of these categories display varying levels of EFD (Zelazo and Carlson, 2020). Hence Craig et al. (2016) describes EFD as a phenomenon of comorbidity (the associated presence of more than one clinical condition), with these conditions and their symptoms varying in severity (Zelazo et al., 2016). However, there is a lack of clarity as to whether these co-occurring disorders exist within a single underlying condition with multiple symptoms or as two or more individual disorders (Lonergan et al., 2019), and understanding the intersecting developmental trajectories of co-occurring difficulties (comorbidities) is imperative to determine their mutual interdependence (Meltzer, 2018; Zelazo and Carlson, 2020). The sections below, therefore, consider the co-occurrence of EFD with ADHD, autism, and dyslexia.

2.7.1 Co-occurrence of EFD in children with ADHD

Several studies have identified the co-occurrence of EF elements in children with ADHD (Schreiber et al., 2014), with various theoretical models indicating the presence of inattention, hyperactivity and impulsivity as EF weaknesses in individuals (Barkley and Murphy, 2011). The primary challenges of behavioural inhibition, cognitive dysfunction, energy deficiency (lack of the energy required to make a certain effort) and a lack of executive control (an inability to plan and monitor) have also been linked to EFD (Brown, 2006). In addition, EFD is also manifest in impulsive behaviour, forgetfulness and subsequently decreased psychosocial skills in cases of ADHD (DeWitt et al., 2019).

However, studies have identified varying findings concerning different EF traits in ADHD. For instance, Holmes et al. (2014) showed how impaired WM in students with ADHD impacts their academic ability. In this particular study, 50 participants aged 8 to 11 with poor WM and ADHD were selected. The findings show that the participants exhibited low WM, in addition to numerous other problems with higher-level cognitive functioning, particularly in behaviours associated with executive functions in ADHD. Hence, multiple domains of these difficulties were identified as affecting this group. In addition, Irwin et al. (2019), based on a sample of 77 children aged 8 to 13, found that their shifting difficulties were caused by several variables, including challenges in reconciling between conflicting rules.

Students with ADHD who lack IC and self-regulation also have trouble with other EF abilities (Jacobson et al., 2018; Burnette et al., 2020). For example, the findings of Stevens et al. (2010), obtained through a study of 152 primary school children aged 7 to 12, showed that children with ADHD manifested challenges in IC, WM, and short-term memory; however, there were no major differences in their responsiveness to external reinforcement. A likely explanation for these findings would be the variance of EFD seen in individuals with ADHD, which further emphasises the importance of assessing individual differences when addressing EF traits in individuals with ADHD.

2.7.2 Co-occurrence of EFDs in children with autism

Various studies have reported EFD in ASD, reflecting on atypical EF processes, impaired mechanisms, and the high-order EF of these children (Ellis-Weismer et al., 2018). The role of EF skills in ASD is particularly significant due to their impact on specific difficulties in ASD, as conceptualised within the framework "Theory of Mind" (ToM) (Jones et al., 2018). ToM addresses "the ability to infer the mental states of other people and to use this information to predict behaviour" (Jones et al., 2017, p. 95), and this has a significant effect on an individual's social interactions. The difficulties conceptualised within ToM include social cognition (Torske et al., 2018) and impairments and stereotypical behaviours (Meltzer, 2018) which have a broader influence on overall quality of life (Friedman and Sterling, 2019).

Pellicano (2007) assesses the functional link between ToM and EF in autism, based on a sample of 30 young children with autism, aged 5 to 6. In order to assess the developmental importance of the relationship between ToM (1st- and 2nd-order false belief) and EF (e.g., planning, set-shifting, inhibition), 40 typically developing children were also included. Findings showed a positive association between ToM and EF in the autistic individuals, supporting the view that EF contributes to ToM development in autistic individuals. In addition, Torske et al. (2018) assess the link between metacognitive aspects of EF and how they relate to social cognitive abilities in students with autism. The study incorporated a sample of 86 children with ASD, aged 6 to 18. Findings indicated that EF components are critical for social skills and cognition (such as emotional and behavioural regulation) in autistic children and in adults.

Indeed, some studies have identified EFD as a primary cause of symptoms of autism in children and adults. The most obvious impairment of EF in autistic individuals is in the domains of WM (Pellicano et al., 2017), planning and CF, shifting attention (Semrud-Clikeman et al., 2014), and responses requiring IC (Van Eylen et al., 2015). Studies assessing EF difficulties in high-functioning autism have also reported substantial challenges in self-regulation domains, including planning, organisation, reasoning and problem solving, faced by such students (Diamond, 2013; Rosenthal et al., 2013).

These challenges suggest that a number of factors may vary the level, severity and extent of EF difficulties in autistic children. For example, Robinson et al. (2009) found no significant deficits in CF in children with ASD in their assessment, but difficulties in planning, IC and self-monitoring. However, Weismer et al. (2018) highlight factors such as students' age, methodology of diagnosis/assessment, and types of EF components examined, and Van Eylen et al. (2015) emphasise that these inconsistencies may persist due to multiple tasks measuring the construct of EF, as well as participant heterogeneity (their cognitive level, the severity of language difficulties and autism). Previous studies have debated variations in the occurrence and manifestation of EFD across different age groups, leading Leung and Zakzanis (2014) to conclude that EF impairment is not a uniform characteristic of individuals with ASD but progresses through childhood to the adolescent stage.

Although Geurts et al. (2014) posit, from the findings of three studies, that 30%-70% of children with autism exhibited difficulties in EF, and Chizary et al. (2020) identify similar evidence from significant studies on the prevalence of EFD in ASD, few studies which have investigated the effectiveness of interventions to address EFD highlight what is effective for groups exhibiting autism (Marzocchi et al., 2020). Furthermore, the increasing prevalence of autism in Saudi classrooms calls for assessing and addressing the variations in EFD shown by this group in particular (Taha and Hussain, 2014).

2.7.3 Co-occurrence of EFD in dyslexia

Research has shown that students with dyslexia have varying EF deficiencies, including in WM, IC, flexibility, use of strategies and fluency (Moura et al., 2014; Varvara et al., 2014). For example, Cartwright et al. (2016) identified issues in relation to reading fluency, including CF (the ability to shift between elements of reading tasks), inhibition (the ability to suppress irrelevant information for better text understanding) and WM (the ability to decode new words, retrieve semantic knowledge and accommodate new information) (Diamond, 2013). Domains that seem particularly affected include academic performance (Engel de Abreu et al., 2014), reading competencies, lack of self-regulation, time management, note-taking and organisational abilities (Meltzer, 2018).

Despite the significance of these domains, few studies have addressed the application of intervention strategies to address EF in this group's educational contexts. Although there have been some evaluative studies, Smith-Spark et al. (2016) report that EF has not been investigated adequately in adults with dyslexia, even though they typically face more frequent problems in the domain of metacognitive processes (WM, planning, inhibition, task monitoring, and shifting and organisational skills) than affective and behavioural aspects. However, Kirkman (2016) did explore technological solutions for addressing various cognitive challenges, including EFD in children with dyslexia, and determined that they could be effective in ameliorating aspects of the planning, organising, time management and self-regulation components of EF. The study also indicated that digital calendars and reminders (notification features), note-taking app features, reminders and digital organisers could help to address these EF cognitive functions.

In conclusion, although EFD is a prominent theme in the existing literature on various diagnostic groups, including ADHD, autism, and dyslexia, there remains a scarcity of research examining these difficulties in the Saudi context (Alsaedi et al., 2020). As Zelazo et al. (2016) demonstrate, the difficulties exhibited under different components of EF may be associated with various forms of a specific disorder; therefore, examination of co-occurrence is required to clarify how two disorders occur together, and how their symptoms interact and coincide in a recognisable profile. Thus, analysis of the variations of EFD in different diagnostic groups is critical in the context of the present study, in order to map their developmental trajectories and learning patterns and determine the proper intervention and strategies for each group. Moving on to examine EF within school-based contexts, the next section considers how EF skills relate to students' academic performance and skills.

2.8 EFS in relation to students' academic development

Research indicates that students' academic readiness and performance are progressively dependent on their ability to set goals, organise, prioritise, shift flexibly, employ WM and self-monitor (Marisa et al., 2020). Therefore, these EF processes are critical for academic achievement (Fuhs et al., 2014) and executing academic tasks, such as reading, writing, literacy, numeracy and related test-taking activities (Schmitt et al., 2017; Meltzer, 2018). Although the impact of EF on academic performance has a range extending from 20% to 70% (Roebers, 2017), Sjowall et al. (2017) state that EF traits in the early years of life predict later academic performance. Furthermore, they also indirectly relate to attention, learning-related behaviour, and already learned academic skills (such as reading, writing and numeracy) (Neuenschwander et al., 2012). The persistent nature of challenges in these areas may proliferate with time, exacerbating the academic-related consequences.

The academic environment needs students to be academically proficient, and those with EFD face particular challenges from new educational procedures, policies and learning schedules which require high-order thinking (Clements et al., 2016). As noted above, students with EFD may be limited in their cognitive capabilities and thus unable to retain attention and focus in classroom activities, lack self-regulation, and struggle with organising and regulating their learning behaviours and planning abilities. Moreover, weak memory may also hinder them from applying the teacher's instructions to complete multiple classroom tasks (Zelazao et al., 2018). Given this, significant attention has been dedicated towards seeking the relationship between EFD and academic functions and identifying the best solutions to improve them (Diamond and Ling, 2016).

Morgan et al. (2019) identified how core characteristics of EF relate to different academic functions: WM is crucial in retaining and managing information about academic tasks, while, CF enables students to determine the changing meanings of things, integrate additional information, and ignore unwanted information. Similarly, IC enables students to control impulsiveness and retain engagement during academic instructions and activities (Allan et al., 2014). The significance of self-regulation and organisation is its use for completing tasks on time and fulfilling academic demands. In addition, Watson et al. (2016) found that planning and organising enable prioritisation, that self-monitoring relates to editing, and that IC relates to note taking. Writing skills are also associated with various cognitive functions, requiring the coordination of different EF skills. Consequently, a lack of coordination in multiple EFs in students with learning disabilities is a critical impairment to consider.

As Watson et al. (2016) note, WM, planning and self-regulation are related to the reading process and to comprehension (Graham et al., 2013). Moreover, inadequate WM (related to remembering which task to do), planning (selecting topic, content, and materials) and self-regulation hinder students from initiating tasks to complete academic assignments, and thence in conducting independent study (Labuhn et al., 2010). In addition to reading and writing, students with EFD have also been observed to have inadequate numeracy skills and to lack conceptual comprehension and computational knowledge (Clements et al., 2019). Several EF processes have been noted as contributing to this, specifically inhibition and WM (Kolkman et al., 2019).

In this respect, Meltzer (2010) claims that academic success in different areas, including reading comprehension, writing, numerical problem solving, summarising and note-taking, requires a student to use EF skills effectively in five core areas (See Figure 2-1). These components require a student to integrate and organise multiple EF processes simultaneously; hence a mix of strategies is helpful when seeking to enhancing EF processing.

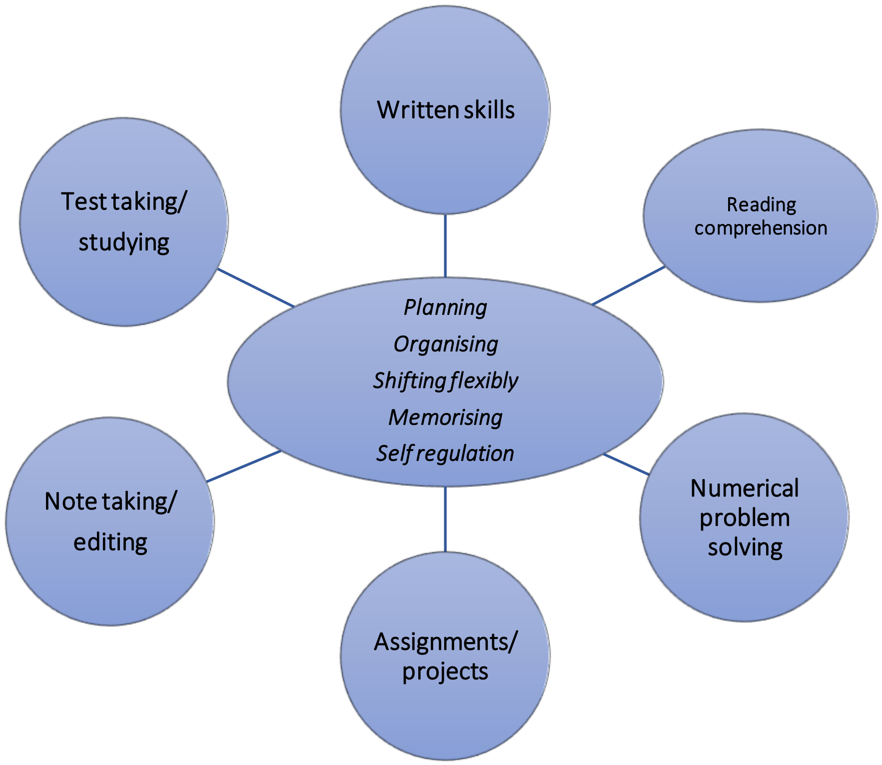

Figure 2-1: Core executive function processes that affect academic performance (Adapted from Meltzer, 2010, p.47)

The relative significance and association of each EF skill varies in terms of its part in predicting students' academic achievement and behaviour. Evidence provided by Morgan et al. (2019) identifies IC as being the most consistent in determining and predicting students' early academic achievements and performance, as it is understood to have direct involvement in a student’s ability to filter relevant information, attend to the teacher's instructions, (Laski and Dulaney, 2015), and resist impulses to withdraw and become distracted or inattentive. Meanwhile, other researchers, notably Cartwright et al. (2017), Nayfeld et al. (2013) and Yeniad et al. (2013) identify WM and CF as being strongly linked to helping students retain information and keep or shift attention from one task to another.

The relationships and predictive power of EF skills in contributing toward students' academic performance have been well-addressed. Cortés-Pascual et al. (2019) confirm EF as being a strong predictor of academic performance in 6 to 12 year-old primary school students; however, they also highlight the role of other factors, including characteristics such as age, gender, and socio-economic status, in moderating the relationship between EF and academic performance, echoing other studies (Thomson, 2018; Kvalø et al., 2019).

Other studies have also determined the relative importance of each EF for improving academic skills in students as they age. For instance, Best et al. (2011) determined the role of WM as being more influential in the early years of primary school, as it develops quickly at that stage, and plateaus during adolescence. The significance of WM is also underlined by Ahmed et al. (2022), who compared its relative importance in the early and later academic years. Their findings suggest that WM at 5 to 6 potentially determines WM at 15, owing to its significant contribution to language and numeracy skills (Lopez, 2013). In addition, Valcan et al. (2020) report that EF in early childhood predicts both current and future academic achievement. Their study obtained a longitudinal dataset of 176 children at the start of kindergarten, and one year later. The EF skills exhibited in the first year were found to determine the reading and writing quality in the next year, leading the authors to contend that early EF development predicts later academic achievement.

As different academic subjects demand different EF skills, research has also determined the domain-specific demands for each EF skill, the roles of other components (age and types of subjects), and their relative contribution to academic performance. For instance, Latzman et al. (2010) explored the demands of different subjects (including mathematics, science and reading) on various aspects of EF in students from 11 to 16, and found that CF relates to science and reading in particular. Similarly, Gerst et al. (2017) identified cognitive functions (inhibition and planning skills) as the strongest predictors of improving mathematics skills in students aged 5 to 11. While WM has been found to be important for reading comprehension (Watson et al., 2016), Sesma et al. (2009) found that WM and planning were important in developing writing skills and understanding the complexities of written texts, whereas IC was more closely linked to mathematics and science skills.

These findings indicate that each academic domain makes specific demands on different EF components. For this reason, it is essential that efforts to ameliorate EFD address the core EF skills: retaining and maintaining information (WM); ability to disregard distractions (IC); ability to execute different tasks (CF); and the ability to anticipate and complete a task (planning/self-regulation). However, the selection and execution of any such intervention depends on the knowledge and capabilities of those involved; therefore, the next section reflects on the importance of teachers' and parents' knowledge about EF skills.

2.9 Role of teachers and parents in addressing EFD

With increasing research into EF skills, practitioners, teachers, and parents are becoming more aware of the significance of these skills (Jacobson et al., 2011), and the roles they can play in nurturing them. Teachers' and parents' conceptions and awareness of students' learning needs and challenges are now being valued and recognised in the educational context (Morgan-Borkowsky, 2012), and there is wider appreciation that opportunities exist in the early preschool years to facilitate EF skills development through the mature guidance of teachers (Neuenschwander et al., 2017).

As the development of EF skills is responsive to different environmental and contextual influences in students' early years, assessing teachers’ insights, knowledge and experiences with EF skills, their associated difficulties, and relevant interventions is vital (Meltzer, 2018). These influencing factors include the teacher's understanding, experience, and expertise in the classroom context, which are imperative in promoting and developing EF skills (Keenan et al., 2020). As Ledermen and Torff (2016) emphasise, students with EFD can be challenging for teachers as they disrupt the normal teaching process, learning activities and school performance. Consequently, teachers require up-to-date and factually accurate knowledge, recognition and awareness of the challenges of EF students, and understanding about how to respond to and manage these students effectively through timely instructions. However, Rapoport et al. (2016) indicate a lack of research assessing the importance of teachers' understanding of EF skills and difficulties, and while some researchers have explored teachers' understanding of EF, and their experiences with interventions (for example, Baum et al., 2018), there is insufficient evidence about teachers' experiences in determining the support and interventions required to address EFD (Rapoport et al., 2016).

This is particularly important because teachers' facilitation throughout the learning process has been identified as a key contributor to improvement in cognitive skills and academic performance (Nancy, 2017). Facilitation is a complex process, guided by a knowledgeable teacher who identifies students' needs and challenges and helps them accordingly, monitoring the process by asking questions to assess learning and performance and repeatedly presenting challenges to develop cognitive competency (West et al., 2019). These scaffolding stages are illustrated in Figure 2-2. Some studies suggest that teacher facilitation is the most effective means of attaining significant improvements (Nancy, 2017), as teachers are well-positioned to find the gap between what is already known and what is yet to be learned, and to try to address these gaps through appropriate strategies and instructions (Graham and Harris, 2007). In the context of this study, Alotaibi (2017) highlights the importance of collaboration between teachers, especially between general and special education teachers to facilitate co-teaching, to enable better planning and clearer allocation of instructional responsibilities.

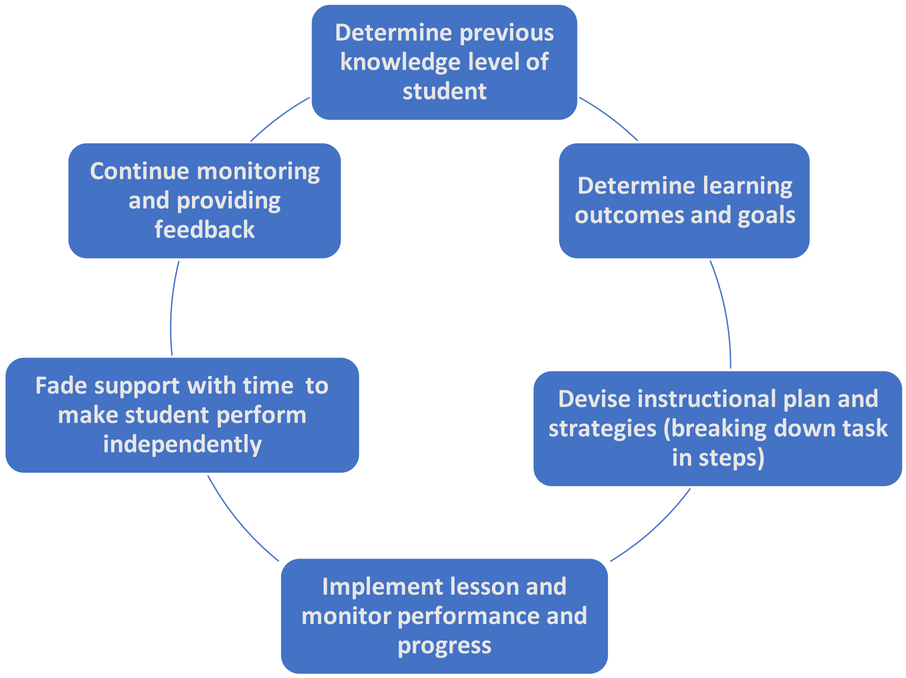

Figure 2-2: Stages of scaffolding (Adapted from West et al., 2019)

The teacher's role and perceptions in executing effective scaffolding determine the overall success of his/her teaching (Reynolds and Daniel, 2018). The teacher's professional aura and expertise, decisions in an instructional context and perceptions toward the scaffolding technique, intervention or technology contribute significantly to its potential impacts on students' learning (Rodgers et al., 2016). Hence, teachers play a crucial role in scaffolding students' cognitive and social development with EF difficulties (Zurek et al., 2014).

The role of parents has been found to be equally critical in addressing and developing EF skills. Wilson et al. (2018) reflect on the importance of parental engagement and involvement in overall academic success, and various educational organisations have identified the significance of parental support. For example, the Education Endowment Foundation (UK) emphasises that parents are integral to supporting children's overall learning and development, and that schools should maximise opportunities to work with them. Indeed, Wilson et al. (2018) reiterates previous recommendations about the role of parents and the home environment in developing high-end cognitive capabilities, in particular in organising, planning, managing time and controlling emotions. More recently, Costley et al. (2020) identified a systematic correlation between parental engagement and the quality of their children's participation (during group teaching sessions) and performance (competence in completing the home task) following a training programme.

Teachers in the classroom and parents at home play an essential role in providing the required assistance to develop EF skills. However, parents are the ultimate caregivers, and Moriguchi (2014) mentions a significant association between their knowledge of behaviour and the development of their child's early EF skills. Furthermore, research has also identified parenting, and the attitude of parents, as significant factors in individual differences in EF (Fay-Stammbach et al., 2014; Nyroos et al., 2018). For example, parents can aid and help structure activities, provide scaffolding to help the child interact, and support their goal-directed actions. Thus, parents' knowledge and understanding of EFD is crucial, from being aware of previous and current developmental milestones to understanding relevant policies and support for EF skills development and the impact of other factors, such as social systems and broader institutional policies.

2.9.1 Teachers' and parents' awareness of EF and EFD

The role of parents is also crucial with regard to understanding their children's cognitive strengths and weaknesses, as this enables them to support and scaffold the children, design goal-directed activities and help to structure the best conditions for facilitating their learning (Zelazo et al., 2015). Đurišić and Bunijevac (2017) emphasise that better parent knowledge and understanding of these issues will facilitate learning at home, and parents will be able to guide the child appropriately with curriculum-related activities. Home-based learning also relates to informing and educating parents about ideas on how they can guide and support their children with homework and course-related choices and activities.

The importance of teachers' and parents' roles in developing EF skills has given rise to numerous studies exploring their awareness and capabilities to address EFD effectively in both the home and school context. Keenan et al. (2019) explored the teachers' role in providing targeted support to promote EF, in particular their presence and provision of intermittent scaffolding to address EFD. Drawing on findings from a focus group study with ten primary teachers, they identified a knowledge gap regarding EF terminologies that limited the implementation of evidence-based interventions and other systemic solutions. The study found a lack of awareness of 'executive function' as a term; however, once the term was explained, teachers typically recognised that EFD was more prevalent in children with neurodevelopmental disorders, including ADHD, ASD and dyspraxia, and children with emotional or behavioural difficulties.

Although less than 40% of the teachers in Keenan et al.'s (2019) study were found to understand the terms or core EF characteristics, such as CF and IC, they were aware of the support needs of EFD. However, they identified a lack of resources that limited the effective execution of individualised assistance and classroom-based interventions. These findings echo Morgan-Borkowsky (2012) who indicated that certain limitations inhibit teachers' propensity to learn and discover more about EF skills, notably the lack of resources available to them. This issue is further exacerbated by limited literature and published books that address teachers' insights into EF skills and provide practical guidance to be used with students. This results in a lack of confidence in designing adequate instructions and strategies to address students' difficulties (Keenan et al., 2019). This signifies a need for domain-specific training, relevant to the particular disorder, to enable teachers to gain sufficient knowledge (of cognitive, behavioural and biological aspects) to avoid misconceptions and to determine the appropriate intervention and strategies to help students overcome EFD (Morgan-Borkowsky, 2012).

Indeed, for any intervention to be effective, teachers must possess the relevant knowledge, competencies, and proficiencies, to enable them to determine the support and scaffolding required (Nyroos, Wiklund-Hörnqvist and Löfgren, 2018). The available research reflecting on understanding and knowledge of EF is relevant to teachers and there is a dearth of studies that talk specifically about parents knowledge and awareness of EF. As Dunlap (2020) reports, teachers' lack of knowledge and understanding of particular behaviours of students with EFD might affect their ability to manage these students and their overall learning trajectory, because this lack of awareness of EF impacts multiple dimensions of students' developmental trajectories, especially the use of appropriate teaching styles (Diamond, 2016), the most effective classroom structure and strategies (Robert et al., 2015), and overall teacher-student interaction. This calls for further investigation of the awareness of teachers and parents, such as the exploration of the Saudi context in the present study, to ascertain their proficiency in determining the best instructional strategies and interventions for students with EFD.

Having examined teachers' and parents' roles and contributions, the following section considers school-based interventions and how they contribute to addressing EFD in students.

2.10 School-based interventions and strategies to address EFD

Students with EFD encounter significant challenges due to a lack of the necessary competencies for functioning appropriately in a school setting (Mermelshtine, 2017), and teachers and facilitators have incorporated numerous EF-focused classroom-based strategies to target the development of domain-general skills (Bierman and Torres, 2016). These skills influence the pace and quality of a student's learning capacity, such as attention control, memory, planning, CF, inhibition and problem solving. The most commonly adopted interventions are computer-based training, game-based learning, physical activities and school curriculum activities (Diamond et al., 2007; Mackey and Hill, 2011; Karbach and Unger, 2014), and studies indicate they can be highly effective. For example, Diamond and Ling (2016) assessed and reviewed a variety of classroom interventions and strategies to address the EFD in students of different ages, and found that they considerably enhanced EF skills. However, there remains a lack of evidence based on a comprehensive examination of the impact of these interventions considering multiple variables. However, as Bierman and Torres (2016) note, there is a lack of empirical evidence regarding which interventions work most effectively to promote EF skills, and what specific interventions can offer to address these students' social, behavioural and academic issues.

2.10.1 Direct and indirect interventions

Specific underpinning characteristics and factors need to be continuously challenged to elicit improvements in EF skills, so any activity, programme or strategy needs to be both engaging and progressively more challenging for the student. In light of this, Otero et al. (2014) categorise different school-based interventions as either direct or indirect, with direct interventions targeting a single EF domain and involve the practice of that skill, and indirect programmes and training addressing multiple EF domains. Their findings showed that direct interventions, for example, computerised training to stimulate WM, produced more significant improvements, while the indirect programmes and training include strategy learning that addresses multiple EF domains and that has been found to produce a substantial transfer effect (Diamond and Ling, 2016).

The literature on school-based interventions for students with EF difficulties has produced differing results, but each demonstrates promise regarding the supportive development of EF skills. However, it is also essential to consider the factors that are influential in accustoming students to an intervention or strategy (Korpa et al., 2020) and which can either support or undermine their EF development (Bardack and Obradović, 2019). Therefore, the following section discusses the factors which must be considered before implementing an intervention for EF development.

2.10.2 Considerations in the selection of intervention and strategies

As Otero et al. (2014) highlight, commonalities exist in all the interventions designed for EFD; however, each construct requires specific intervention to target a particular deficit. As different interventions therefore produce differing outcomes for specific EFD characteristics and diagnostic groups (Otero et al., 2014), empirical evaluation is required. Diamond (2012) delineates general principles that must be considered by teachers and practitioners when selecting an intervention for students with EFD. For example, an intervention should produce a narrow transfer effect, constantly challenge the EFD, entail repeated efforts, involve practice and execution of activities to measure EF gains, and produce measurable outcomes and effects.

Diamond (2012) also cites age and current level of developmental functioning as essential factors to be considered, as the two factors run parallel in the developmental trajectory. This is supported by Dunlap (2020), who also found that the effectiveness of any EF intervention is related to the developmental stages of learning (Garbacz et al., 2018), with evidence pointing to greater success in addressing key EF skills, such as attention control, WM, planning, organising and self-regulation, if support is provided during the early school years. However, Black et al. (2017) cautions that there is a lack of consensus on age specificity for an intervention to work (Martoni et al., 2016), as the findings of Benzing et al. (2019) provide evidence of improvement in EF skills in older students as well, and Samuels et al. (2016) suggest that selecting the proper intervention is more important than the timing of that intervention. Therefore, student age is a factor in the successful execution of classroom intervention; however, considering the above, it has been proposed that age-specific interventions should be adopted to achieve better results in academic contexts (Coyne and Rood, 2011).

Furthermore, the nature of neurodevelopmental disorders, such as ASD and ADHD, determine the selection and effectiveness of any intervention. Hence, teachers need to be able to select from a variety of approaches and interventions, administered individually or in groups, to address the cognitive aspects of EFD. Detailed diagnostic information will help teachers select the appropriate programme for their students; however, the present study also examines what other dimensions correlate to teachers' priorities and expectations in choosing an intervention or strategy for students with EFD. The following sections explore classroom-based interventions to support students with EFD, and the instructional and scaffolding strategies they entail.

2.10.3 Classroom-based interventions

Several classroom-based interventions have been illustrated by previous studies, and some of the most prominent are described below.

2.10.4 Group and game-based activities to improve EF skills

Classroom-based interventions in group settings, such as playing games in a group producing multiple advantages (Cardoso-Leite and Bavelier, 2014), have been found to produce effective gains in EF skills (Blumberg et al, 2019;

Plass et al, 2020). These games offer constant challenge in training specific domains (addressing different EF skills) and work best when adapted and customised according to students' learning level (Kurth et al., 2015). For instance, Benzing et al. (2019) explored the effectiveness of classroom-based interventions and strategies to improve EF skills in older students with EFD. Their study featured 118 students aged 10 to 12 from eight different classes, who underwent cognitive game-based intervention, directly and indirectly targeting different EF skills. The findings demonstrate that 'multimodal' aspects of training, targeting multiple EF domains, constitute a more effective approach than a one-dimensional method (such as the single computerised training) (Cardoso et al., 2016; Diamond and Less, 2011; Otero et al., 2014). Another benefit of this approach is that it produces a broader transfer effect than direct training (See 2.10.1).

In another study, Macoun et al. (2020) identified game-based gains in WM by assessing the efficacy of cognitive game-based training in school-aged students with autism. The training used a hybrid approach (direct and indirect training), using both game features and repetitive exercises employing metacognitive strategies that helped to develop the attention and EF abilities of the students. A total of 20 students with autism, aged 6 to 12, undertook training for a period of eight to 10 weeks under the guidance of an adult trainer. The findings showed improvements in WM and attention, and also in the students' mathematical skills. Moreover, parents and teachers reported that the students showed improved emotional regulation, CF and social skills.

Moeller (2019) suggests that, among interventions for EF, small group-based interventions produce particularly meaningful results for different EF components, as they are easy to execute, avoiding major disruptions in the classroom, and enabling teachers to use minimal resources to address EF challenges in several students. In one study by Rothlisberger et al. (2012), 135 students aged 5 to 6 were trained in a group-based intervention, with different tasks aimed at addressing WM, IC and CF. Each small group practised for 30 minutes, three times a day for six weeks, and positive results in each domain were identified. These results were superior to those from individualised and computer-based training, which typically requires more resources and is domain-specific, that is, addressing only one skill at a time (Rothlisberger et al., 2012).

In addition, Riccio and Gomes (2013) suggest that the inclusion of effective metacognitive and instructional strategies in group-based intervention addresses EFD more efficiently. They found that clear teacher instructions directed students' behaviour more effectively towards learning, and helped to improve students' self-monitoring and self-regulation. These authors suggest that the use of such strategies in small group training has the potential to produce long-lasting impacts on EF skills but further research is required.

In view of the effectiveness of group-based intervention for improving EFD, these associations will be assessed in the Saudi Arabian context to determine how teachers incorporate group-based or whole-class intervention in a mainstream setting.

2.10.5 Computerised training

The potential effectiveness of computerised interventions is enhanced by their appeal to children with EFD, especially when they resemble videogames (Scionti et al., 2020). Computerised training is considered to be effective when executed in conjunction with other strategies and approaches, particularly repetitive practices and teacher reinforcement, especially in enabling students to engage in tasks to improve WM or attention (Dovis et al., 2012; Diamond and Lee, 2011). While some researchers have reported fewer gains in other EF domains, notably in inhibition (Thorell et al., 2009), others do mention improvement in IC with computerised training (Diamond and Ling, 2016). This discrepancy may relate to underlying demographics and other contextual factors, such as participants' age, which can affect the influence of an intervention and the resultant gains. There is, however, agreement in the literature that the role of reinforcement is imperative in computerised interventions, specifically adding external incentives and reinforcers, such as game-like features or add-ons, can help optimise motivational levels and increase cognitive performance (Dovis et al., 2012; Cartwright et al., 2020).

Although computerised interventions for EFD, including WM training through CogMed (Diamond and Lee, 2011), computerised attention training, computerised academic support, and other specially designed games (Rabiner et al., 2010; Diamond, 2012), are used in school settings, research has produced mixed results regarding their efficacy and transfer effects (the ease with which the trained EF skills can be transferred to different cognitive tasks). Various studies report gains with computerised training, notably Diamond (2012), which claims that strong evidence exists for computer-based training improving EFS in children, and Wong et al. (2013) who identified potential improvements in WM in a group of Chinese children with cognitive deficits after high intensity computerised training. However, Bergman Nutley et al. (2011) targeted a sample of 100 students with computerised WM training and found that, while results indicated improved WM in 4-year-old students, the transfer effects were not generalisable to non-verbal reasoning tasks, revealing the domain-specific nature of this training.

In addition, while Melby-Lervag and Hulme (2013) found in their meta-analysis that computerised WM training could be efficacious in other cognitive constructs, such as non-verbal and verbal abilities, IC, and attention, they propose that this training produces only short-term gains that cannot be generalised to other EF constructs or even maintained in follow-up experiments. Otero et al. (2014) also argue that the number of sessions required to see improvement involves intensive efforts and repetitive sessions that require time, resources, and services. Hence, this aspect of EF training requires consideration when planning interventions to use in schools, especially in a context like Saudi Arabia where lack of adequate resources has been identified as an issue (Ahmed, 2015). Therefore, after identifying how different elements determine the effectiveness of computerised interventions to address EFD in Saudi classrooms, the present study will evaluate how these and other factors serve as facilitators or barriers as Saudi teachers seek to implement computerised interventions for students with EFD.

2.10.6 Differentiated instructions and strategies

In contrast to studies which focus on the development of EF skills through interactive mediums and tools, Chan et al. (2019) explored the benefits of adopting a strategy-oriented approach to facilitate the effective development and use of EF skills. Their study involved 64 students aged 6 to 9 and assessed the transfer effects of training WM strategies through a novel problem-solving task. They found that the use of strategy-based training enabled participants to recall and execute the trained strategies in a different context, even when they had no prior experience of that context. Key to this success was the use of clear, practical instructions and the selection of strategies that were easy to use. Hence, for classroom interventions and programmes to be effective, teachers should consider the importance of developing practical strategies, and ensuring that instructions are explicit and concrete.

In this respect, Meltzer et al. (2007) suggests that teachers follow the principles of practical strategy instructions. The characteristics of adequate strategy instructions should entail: (a) linking the strategy to the curriculum and content, (b) explicitly teaching metacognitive strategies through frequent modelling and repetition, (c) a structured and systematic way of teaching, again through frequent modelling, (d) feedback and opportunities for repeated practise and enabling students to understand their strengths and weaknesses and (e) specific strategies to help accomplish a task (such as breaking the task down into small, realisable steps). Teachers should thus ensure that strategies fit with the curriculum and take account of the kind of EF skills development which students in their classrooms require (Chan et al., 2019).

Strategies to help improve students' academic performance and direct behaviours include differentiated instruction, individualised educational programmes and one-to-one instructions. Kryza (2013) examined the use of differentiated instructional practices and strategies in the classroom, and found that they were effective when combined with clear learning targets. These targets, along with differentiated instruction, should be aligned with a developmentally appropriate curriculum and balance students' social development with academic instruction in order to build their EF skills. She also finds that, in order to effectively execute strategies during instructional practice for developing EF skills, teachers need to teach them deliberately and clearly. This echoes Rosenshine (2012), who found that effective teachers conduct guided practice, and spend more time on it; they also prompt questioning, and invest time in exploring the students' understanding up to the point of independent practice.

Implementing strategies that facilitate the applicability of interventions to other contexts can also improve efficiency, especially if parents can use them at home, by assisting with homework or other activities, to encourage students to reinforce these approaches. Greenstone (2011) mentions some specific strategies employed in the classroom - and potentially in another context - to help develop self-monitoring and self-regulation skills in students, including colour-highlighted and partitioned notebooks, time- and work-organisers, calendars to keep track of schedules, appointments, and deadlines and monitor progress, and checklists and memory aids. Greenstone (2011) stresses that these strategies have essential associations beyond the academic years because they tend to improve self-reliance and self-knowledge skills, and are easily generalisable to a different context (Doabler et al., 2012).

As Meltzer (2018) notes, "all students benefit when EF strategies are taught explicitly and systematically incorporated in the daily classroom curriculum" (p.288). This is in accordance with Scruggs et al. (2010), who identified high effect sizes for systematic teaching and for strategies that assist students to think systematically about the content to be learned. In this context, the following section explores scaffolding as an effective strategy that, if incorporated into the instructional approach, provides the most explicit and systematic option for students with EFD (Van Bramer, 2011).

2.11 Scaffolding as an approach to teaching instruction

Scaffolding as an instructional technique is widely used to support less capable students, with the more capable or knowledgeable person in the learner's context playing a primary role in making overall learning manageable (Lin et al., 2012; Van de Pol, 2012).

2.11.1 Theoretical foundations of scaffolding

Wood et al. (1976) were the first to use the term ‘scaffolding’ as a metaphor in the learning context, and its theoretical foundations relate to Vygotsky's theory of learning, that is, learning and cognitive development occur in a social context. Specifically, scaffolding develops important learning aspects related to students' needs to facilitate and expedite learning through contingency, intersubjectivity, and transfer of responsibility (Lin et al., 2012; Van de Pol, 2012; Van de Pol et al., 2010). Scaffolding research is primarily qualitative and descriptive (Gibbons, 2002; Echevarría et al., 2017; Ruiz de Zarobe and Zenotz, 2018); however, researchers have reached consensus on the underlying goal of scaffolding: student independence and self-regulation (Van de Pol et al., 2010).

There has been extensive use of the scaffolding metaphor in the area of instruction (Broza and Kolilkant, 2015), and it indicates necessary but temporary support. Within the classroom, teachers (or More Knowledgeable Others [MKOs]) offer support to help students learn to develop skills, concepts and abilities; however, with progressive learning and acquisition of skills, this support is gradually reduced to develop independence and self-regulation in the students (Major and Warwick, 2019). Therefore, the MKO is the most important element of scaffolding strategy; however, their support is aways temporary, offered only until the student internalises the skills and develops cognitive systems to more advanced levels (Vygotsky, 1978a). In this way, the scaffolding strategy's overall goal is to develop students' independent and self-regulated learning capabilities and practical problem solving (Echevarría et al., 2017). These common characteristics and processes are summarised in a conceptual model, shown in Figure 2-3 below:

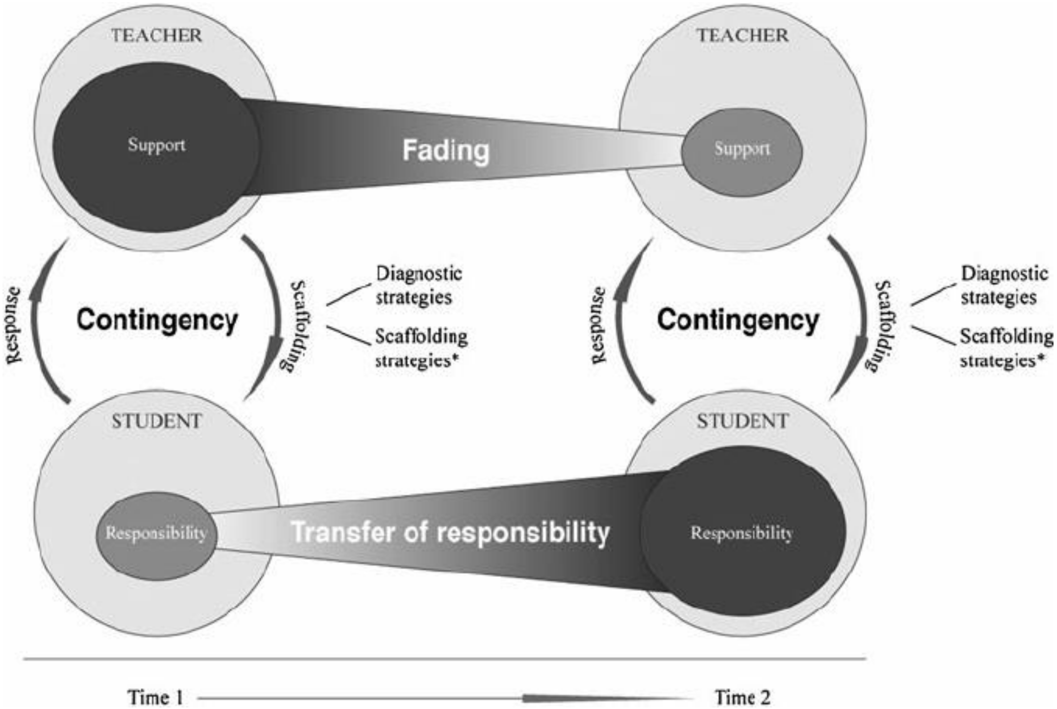

Figure 2-3: A conceptual model of scaffolding (Adapted from Van de Pol, 2010, p.4)

Hammond et al. (2012) identify various facilitative steps that tend to make scaffolding more effective. These include (a) recruitment, which stimulates the student's interest or attention, and their determination to complete the task required, (b) reducing freedom (taking over activities that the student is unable to execute yet), (c) direction maintenance (keeping the learner focused and directed on task completion), (d) highlighting critical features (identifying expected performance state), (e) frustration control (regulation/control of negative behaviour towards learning tasks through reinforcement and motivation) and (f) demonstration (modelling the task for students to imitate) (Hammond et al., 2012; Raiser and Tabak, 2014; Cartwright et al., 2020). These underlying steps help develop student regulation (through frustration control), cognition (reducing freedom in tasks, marking essential features) and demonstration (Feng and Chen, 2014), and enable organisational abilities, areas which are especially important for students with EFD (Echevarría et al., 2017).

Vygotsky (1978) posits that social interaction is fundamental for establishing self-regulation, and research shows that strategies which facilitate maximum social interaction, such as scaffolding, can be effective in addressing EFD (Amado et al., 2016; Sosic-Vasic et al., 2017). Findings from previous research also emphasise that teacher and parent interaction significantly influences EF development (Diamond, 2013; Yu and Smith, 2016) as these students rely more heavily on instruction and assistance until they develop the relevant skills (Schwarz and Bakers, 2016; Major and Warwick, 2019). Another argument is that learning occurs through effective interaction with the environment and others, and not in isolation. To achieve this, Tomlinson (2017) proposes that scaffolding strategies should operate from the macro to micro level: from planning the curriculum/content to determining the interactional scaffolding required, with frequent interaction between teachers and students with EFD to enable their meaningful learning.

2.11.2 Providing appropriate instructional and verbal support

EFD improves when EF skills are directly and continually challenged (Diamond and Lee, 2011), so contingent interaction with teachers during scaffolding, then the fading of this support, ensures that appropriate levels of challenge are provided. Moreover, the amount of time spent on explanation, demonstration and procedure execution contributes to EF skill enhancement, explicitly promoting a child's self-regulation skills (Ursache et al., 2012). However, Wilson and Devereus (2014) point out that students with cognitive challenges should receive instructions that are challenging but achievable with additional support. This instructional approach requires teachers to balance instructions that are linked to curriculum and materials with appropriate instructional scaffolds. However, studies identify that teachers who are not sufficiently knowledgeable or not effectively competent, may overprotect students, which can diminish the rigour of instruction and limit the students' ability to progress (Athanases and de Oliveira, 2014).

Lewis and Carpendale (2009) assert that teachers and parents use scaffolding to assist the child with a structure, with a view to developing their cognitive performance and behaviour. This involves facilitating the child's engagement in a complex task either through verbal (prompting through questions) or non-verbal (attention redirection approach) scaffolds that help with developing the shifting of responses, catching the child's attention and controlling his/her unwanted responses. Mathis and Bierman (2015) examine different aspects of instructional and verbal scaffolding to develop cognitive competencies in students. These include directive verbalisation (telling students what to do) and elaborative verbalisation (commenting on their action/performance, such as questions like "What do you think about…?"). These elements prompt students reasoning and thinking skills, as well as self-exploration, leading to development of self-regulation skills (Bonawitz et al., 2011). They also provide a way to engage students in problem-solving discussions and improve their flexibility to interpret a situation in different ways (i.e., CF).

Hammond et al. (2012) explore the effects of scaffolding on a child's problem-solving and EF development and illustrate that scaffolding at each antecedent age influences the child's next progressive year. A total of 82 children aged between 2 and 4 were engaged in different EF tasks (problem-solving puzzles) and guided assistance (scaffolding) to examine the improvement in EF skills over time. The findings showed that scaffolding executed at age three had a direct effect on the child's performance at age four, and that the child's verbal abilities developed at age two had an indirect effect on performance at age four. This study highlights the need to consider different age groups of children with EFD, in addition to the role of scaffolding-based improvement in EFD. Taber (2019) identifies another vital aspect of instructional scaffolding for EF students, that is, one size does not fit all; all EFD students are different in terms of their diagnostic group and disorder. Hence, employing a general scaffolding strategy may limit the effectiveness of explicit instructions and inhibit the development of desired skills. De Oliveira et al. (2020) indicate that teachers need to be prudent when selecting scaffolds and strategies, and considering the goal of developing EF skills and using scaffolding appropriately.

2.11.3 Scaffolding to address specific EF functions

The use of scaffolding in the development of EF skills relates to the argument that EF and self-regulation skills correlate with parental support, instructional modelling and interactive teaching behaviour (Bernier et al., 2012; Crossley and Buckner, 2012; Cuevas et al., 2014). Numerous longitudinal studies have demonstrated that effective scaffolding strategies help to improve WM and CF (Bernier et al., 2010), and cross-sectional studies have observed that scaffolding is related to improvements in IC and general cognitive skills (Hopkins et al., 2013, Mendive et al., 2013). Positive correlations have also been found between the use of occasional instructional support as scaffolding and enhanced IC in students with EF deficits, specifically in classrooms with higher-quality interventions (Weiland and Yoshikawa, 2013). Bardack and Obradović (2019) also used scaffolding practices to enhance inhibitory, WM and CF functions and develop desired behavioural outcomes. Their results support the notion that a teacher's EF-related scaffolding practices positively correlate to developing the required EF skills and promoting control, attention and CF through interactive teaching practices (Deater-Deckard and Bell, 2017; Shaffer and Obradović, 2017).

2.11.4 Quality of teachers' scaffolding behaviour

Scaffolding is strongly associated with facilitating students' developmental outcomes, but it is significantly related to different quality measures. These include the quality of teachers and classroom processes (interactions) in relation to the development of EF skills (Fuhs et al., 2013; Shaffer and Obradović, 2017). The characteristics and individual differences (EF traits, expertise, and knowledge) of teachers and parents to execute effective scaffolding also come under this context of quality measures (Deater-Deckard and Bell, 2017; Shaffer and Obradović, 2017). Previous research has emphasised the importance of the interlinkage of parents' and teachers' characteristics (for example, their EF and self-regulation skills) and their ability to scaffold to develop EF skills in children (Hammond et al., 2012; Crossley and Buckner, 2012; Cuevas et al., 2014; Mazursky-Horowitz et al., 2018). However, the focus has often been on parental scaffolding and quality of behaviour (Deater-Deckard and Bell, 2017; Shaffer and Obradović, 2017), and less attention has been paid to the quality of the teacher's behaviour and its impact on overall EF development.

Some recent studies have addressed this gap, and they indicate that teachers' displays of EF-related behaviours and their scaffolding practices are vital for developing and maintaining EF development (Obradović et al., 2017). For example, Mazursky-Horowitz et al. (2018) indicate that the quality of teachers' scaffolding instructions is correlated with their EF skills to manage students' behaviour, deliver instructions in a structured way, and use activity time productively. They found that effective scaffolding could be established if teachers use their IC to control distractions in the classroom and exhibit CF in giving instructions by flexibly shifting the focus of class between activities and the learning needs of the students. Teachers should possess the necessary skills to maintain a calm, well-managed atmosphere and keep track of competing student demands (Bardack and Obradović, 2019); however, those who exhibit poor scaffolding skills, face more challenges in maintaining control, attention and behaviour, and demonstrate an inability to develop EF skills in children. Therefore, it is essential to consider how teachers utilise and execute their own EF skills during scaffolding instructions.

Research by Bardack and Obradović (2018) corroborates this perspective and shows that teachers' demonstrations of EF-related behaviour and scaffolding significantly predict EF improvements in elementary-level students. Their study involved a diverse sample of 813 students (aged 8 to 12) and 33 teachers and incorporated observation protocols to reliably measure the teachers’ EF-related activities, behaviour, and scaffolding. Findings showed that specific teaching strategies (scaffolding in particular) enabled students to use and exercise their EF skills individually after the shift of responsibility. The authors also deduced that scaffolding strategies (contingent instructions, step-by-step lesson plans, prompts, reinforcement, modelling, questioning, practice and feedback) could engage students in employing their EF skills to become more self-reliant, and to plan and organise their tasks to meet academic demands in the classroom.

2.11.5 Scaffolding the use of digital or technological measures

Cameron and Morrison (2011) underline the significance of the teacher's orientation and organisation in engaging children in interactive activities when using digital or technological measures to enhance EF skills. Teachers' proficient use of technology leads to the transfer of responsibility through contingent teaching (temporal, instructional and domain) aspects, and Van de Pol et al. (2010) note that the scaffolding metaphor is appealing because this proficiency helps teachers to structure learning opportunities and mediate students' learning successfully by offering the correct help. Thus, the intent behind assessing the use of scaffolding to introduce technology in education is fundamental.

The study by Macoun et al. (2020) offers empirical evidence for the use of both scaffolding and technology-mediated intervention/instructions. The study incorporated game-based cognitive training to address EF processes, mainly attention and self-regulation, in 20 autistic children aged 6-12 during a period of eight to ten weeks. The game was Caribbean Quest CQ, a complex game that adopts a hybrid approach to address attention in students through repetitive practice, with hierarchical levels and tasks graded to enable students to complete exercises. The game design was shown to aid the teacher's instructions and metacognitive strategies, that is, game-specific strategies (rehearsal, chunking, and copying), and scaffold the acquisition of metacognitive strategies (modelling, good listening, following instructions and feedback). This was accomplished through different difficulty levels and increased WM demands within the game, which challenged students to reach the next level. Low frustration and tolerance levels and deregulation of emotions were also controlled through scaffolded support which retained students' attention and engagement to achieve task completion. Both teachers and parents reported improvement in EF domains, including improved focus and attention, self-regulation (improved patience and tolerance while doing tasks and control of emotional outbursts), organisation, and academic performance. Teachers also reported that these gains were accompanied by an increase in unprompted strategies by children, such as repeating things aloud, the use of visual schedules and timers, and self-encouraging statements from students. The latter finding has important implications for future research to assess the generalisation of EF skills learned through hybrid and multimodal approaches (i.e. using technology) as well as cognitive interventions, and process-specific strategies and approaches by teachers.

One of the imperative dimensions associated with effective EF development is practical teacher-student interaction. Quality teacher-student interaction fosters guided exploration and learning of missing EF skills (Bernier et al., 2012). The underlying logic to this perspective is that high-quality scaffolding instructions and one-to-one guidance that is sensitive and responsive play a key role in EF skill development (Bernier et al., 2012) by cultivating student-sensitive and supportive classroom environments. Contrastingly, non-responsiveness and lack of guided assistance predict delays in EF development. Van de Pol et al. (2010) also add that improved classroom strategies and differentiated instruction from teachers are the foundation for teacher-student interaction and measuring EF skills in students.

In addition, the guided instructions provided by teachers are enhanced if five core teaching skills are maintained, namely: providing contingent attention to facilitate positive learning behaviour, motivating learning attempts through praise and rewards, effective classroom structuring and planning, and maintaining positive interaction with students to facilitate a higher level of learning engagement (Oliver, 2007). Therefore, scaffolds must be executed appropriately, monitored, and adjusted over time to move students towards the desired goal. However, previous research has also identified certain drawbacks and challenges associated with this approach. For example, Van de Pol et al. (2015) mention that relying too heavily on contingent assistance will not lead to actual improvements in EF. Therefore, the abovementioned aspects should be considered as aids to allow students to develop the intended skills in conjunction with explicit instructions and practice until they can execute the tasks independently.

Despite considerable literature on the role of scaffolding as a practical instructional approach, there is a paucity of research on how teachers employ it in the Saudi context, particularly its use alongside other interventions and approaches to address EF difficulties in different diagnostic groups. The examination of scaffolding as an instructional strategy in the present study will help to develop an understanding of its contribution to executing technology-based strategies correctly for these students. The study will also assess how teachers and technological aids predict EF-related developmental outcomes in students in Saudi classrooms.

Having explored EFD, its co-occurrence, the strategies adopted to address it, and the significance of scaffolding, the next part of this literature review examines the role of technology in addressing EFD in greater detail. In particular, it considers the affordances offered by technology, and the empirical evidence which supports its use in this context.

2.12 Role of technology in addressing EFD

Due to the challenges faced by those with EFD, increasing efforts have been made within the medical and educational domains to develop interventions and technologies to meet with their educational and learning needs (Meltzer, 2018). Assistive and instructional technologies have been found to support students in both their schooling and later professional lives by helping them to complete tasks as directed, schedule tasks and activities accordingly, organise work and education-related information, and multitask (Peterson-Karlan, 2015). Indeed, Vahabzadeh et al. (2018) assert that technology-based tools in education have proven to be more efficient and effective than traditional instruction, not least because interaction with the technological interface enhances students' motivation. For teachers, technology has facilitated planning (preparation of lesson plans) and assessment (using technology to enhance feedback processes) (Eckhouse and Carroll, 2013). As a result, computer-assisted interventions are being rapidly integrated into pedagogical scenarios for educational software, games and digital media, (Ljung and Djarf, 2008), and experts are now examining the role of technology in educational settings, and the benefits that result from its incorporation into all aspects of instruction (Alkhalidi ,2014). Efforts are also being made to identify gaps that need addressing using creative activities that teachers could pre-design for their students (Bradley et al., 2015; Hallahan et al., 2020).

2.12.1 The benefits of interactivity

The interactive nature of technological devices enables students with numerous cognitive difficulties to engage with them in different ways, allowing them to tap, press, drag and swipe on the screen, and stimulating their senses and enhancing attention and engagement with interactive sounds, visuals and animations (Marsh et al., 2017). It can also improve students' self-confidence and independence as they receive feedback on their performance immediately (Northrop and Killeen, 2013). The multimodal features and touch-based components of technology also make it easy for teachers to design instructions and curricula according to the learning needs of their students (Woloshyn et al., 2017). As a result, the integration of tablets, iPads and interactive applications has become increasingly common to address different learning and cognitive difficulties (Geer et al., 2017).

A growing body of research suggests that adopting such technological tools (whether devices or applications) is making a noteworthy contribution to addressing EFD in different diagnostic groups and may also help students to overcome other associated challenges (Wu et al., 2019). While research has indicated that students with EFD find it harder to follow and benefit from some cognitive training due to the challenges they face in maintaining their attention and focus, following directions, and moving from one task to another (Park et al., 2017), high levels of student engagement in technology-aided learning have been reported by both teachers and parents (Macoun et al., 2020). For example, Neely et al. (2013) incorporated the iPad into pedagogical instructions for students with autism who showed several cognitive challenges and found that, relative to traditional techniques (paper/pencil teaching methods), students exhibited a higher level of academic engagement when using the devices. Moreover, they also reported that iPads were a motivational factor to complete a task that was previously unattainable with traditional instructions, suggesting that the iPad may effectively improve shifting and transitioning skills in students with autism. Perfitt et al. (2013) also note that the iPad is a visually preferred medium that enables switching between activities, context, and situations, and yields improvements in organisation and self-regulation skills through applications that provide visual schedules, visual timers and other similar features.

2.12.2 The benefits for EF development

The integration of technology in the educational context provides significant opportunities for improving students' achievement, and evidence supporting the adoption of technology-based learning to enhance EF skills development indicate the educational benefits of these tools (Okolo and Diedrich 2014; Rachanioti et al., 2019). The specific intent of their integration and the main benefit for teachers is to develop the potential for student academic learning and EF enhancement, and several studies support the case for technologically mediated training and instruction improving several domains of EF (Marzocchi, 2020; Dunlap, 2020), particularly IC, self-regulation, WM and attention. For uniformly academic concepts, such reading, numeracy and writing, this is realised by keeping the student engaged with the learning content on devices. However, because EF skills are cognitive processes, multiple cognitive teaching practices and interventions effectively improve specific targeted gains in different domains of EFD (Dunlap, 2020). Schwartz (2014) finds that the diversity of applications and programmes available and the multimodal mechanisms (audio, visual and sensory) they offer provide a powerful tool to address EF weaknesses and deficits and can potentially compensate for decreased WM, ineffective time management, poor planning and organisation, an inability to initiate task, and poor memory. However, Hansen and Richland (2020) caution that the goal of teachers should be technology integration rather than merely using it to access the multimodal features of its audio-visual dimensions. That requires a planned and purposeful supportive routine, with curriculum goals to involve students in the learning process using technology.

The integration of educational games and applications under the domain of "computer-assisted interventions" for young students with EFD has attracted greater attention in recent years, due to the growing awareness of the support they can provide (Rachanioti et al., 2019; Benites et al., 2020), especially in relation to enhancing attention, interest and IC. For instance, Huber et al. (2018) explored the role of screen-based intervention for students aged 3 and above with WM and other EF-related challenges. Findings indicated that the tactile interface of digital applications, the responsive features of educational programmes, and the subsequent feedback enabled students with EFD to engage, interact and repeat the steps of the learning tool several times, improving their memory due to prolonged focus and attention. The impact of a variety of technological tools on students' overall performance has also been examined, along with their availability, cost, and range of features (Axelsson et al., 2016). Schwartz (2014) in particular explores the use of such tools in different EF-specific domains, for example, addressing WM through applications such as Notability, Evernote, and E-notebook. These tools enable students to pay attention during a lecture, take more complete notes and record audio through software. Google Calendar and similar software is also easily accessible through devices to facilitate students' planning, organising, and time management. Such tools enable students and teachers to set due dates, develop to-do lists, schedule classes, organise meeting notes and set reminders. Furthermore, by assisting in the development of organisational skills, these digital graphic organisers ease the difficulty of developing written material, essays, reports and projects (Kellems et al., 2016; Hughes and Reghan, 2019).

Research suggests that learning happens more effectively via a medium that facilitates cognitive engagement and makes the learning process meaningful, guided by specific goals and socially interactive mediums. As Hirsh-Pasek et al. (2015) elaborate, technological tools serve as a motivational and facilitating medium and an interactive learning platform in the educational context. In addition, for strategies and interventions to be effective and maximise EF gains, certain features are highly recommended, namely, that tasks are designed sequentially or hierarchically, that they become increasingly difficult, and that they involve an increasing intensity of practice and repetition of learned material (Macoun et al., 2020). As the discussion above indicates, these measures help to set the ground for effective learning, and technologically-mediated learning through devices and applications makes them more easily available within an educational context.

Informed by the literature on technology-based improvement in EFD, this study will explore the use of technology-based tools in the Saudi context. It will further assess the efficiency and effectiveness of both traditional instruction and technologically-mediated learning for EFD (Noreen et al., 2019), examining the role of technology in the Saudi classroom and the way teachers use different technological affordances to yield educational benefits for students. In light of this, the following section will highlight the technological affordances potentially compatible with students with EFD.

2.12.3 Technological affordances for students with EFD

The effective integration and use of technology for the purpose of addressing learning and cognitive difficulties requires a deep understanding of its technical functions, features and capabilities (affordances). There is a shortage of literature on technology's capabilities to address EFD, especially in the Saudi context. However, Fischer et al. (2010) note that technological solutions accommodate cognitive, sensory and physical impairments in several different ways, and Almethen (2017) cites increasing students' motivation, directing them to learn, and allowing lessons in the classroom to be customised to meet individual needs. Table 2-2 summarises the affordances technologies can provide in addressing EFD.

Despite these advantages, there are criticisms of the use of technology to address cognitive difficulties, including that it may lead to social isolation (Kinsella et al. 2017), can be distracting (Neiterman and Zaza, 2019), may hinder skill improvements in some settings, and cannot be a fully-fledged solution in all learning contexts (Sinnari et al.,2018). Equally, the available literature suggests that teachers cannot always distinguish between the technical and educational functions of technological tools (Valanides and Angeli, 2008), nor are they typically informed about the underlying cognitive processes required to perform activities using a particular technology (Yoon and Hedberg, 2005). Hence, their awareness and effective use of technological affordances is directly related to the provision of training and professional development (Vásquez Astudillo et al., 2022).

Table 2-2: Affordances of technologies in addressing EFD

Technology	Technological affordances	Pedagogical affordances
iPads/tablets	• Portability • direct interface • integrated apps • audio-visual interactive platforms with touch screen • simple controls make them appropriate for in-class work (Courduff et al., 2016) • easy to use • multi-sensory experience for students • direct communication and quick visualisation; more cost-effective than textbooks (Beal and Rosenblum, 2018) • computerised tasks: verbal (standardised) instructions given via headphones alongside visual interactive instructions on the screen • eliminate instructor bias • limit the cognitive demands associated with social interactions (Berg et al., 2020)	• written cues, verbal and animated prompts, and unlimited instructional trials • valuable classroom discussion in groups (Montrieux et al., 2015) • stimulating critical thinking, connect with other students, generate ideas (Bannister, 2015) • individualised teaching and learning (Young, 2016) • personally, addressing each student (Fisher et al., 2013) • enabling students to take charge of their own learning (Xin and Leonard, 2015) • improvement in on-task behaviour; reduces the need of teacher prompting in the classroom (O'Malley et al., 2014)
Interactive smart boards	• share one screen/interface with multiple students	• accomplishment of many academic goals, such as spelling, reading, writing and mathematics, in a short period of time in a collaborative learning session; highly engaging form of instruction through video modelling (McKissick et al., 2018) • providing written or pictorial explanations for the instructions, showing videos or interactive presentations • providing equal participation opportunities while creating a fun and exciting learning environment (Elmahdi et al., 2018) • engaging all students to participate even if they are shy or quiet, hence improve social skills and interaction

Computers and laptops	• Computer-Assisted Instruction (CAI); integrated classroom settings	• motivating students to engage in active learning, as well as increasing the amount of feedback for both teachers and students (Suárez-Guerrero et al, 2018) • enabling design of a wide range of classroom activities and outcomes-based learning materials (Habler et al. 2015)
Mobile applications and tools EF-friendly apps on iOS and Android: (home routines, alarmed-reminder timers, inClass, My Homework) Cognitive, EF applications (games)	• software (personal data software) • in-built mobile tools and programmes: calendars, organisers, notes, reminders, schedule apps; which can be modified according to students' needs (Wagner et al., 2020) • child-friendly EF applications (compatibility with level of reading and writing ability a child possesses, or the limited attention span of a child) allow shortening of task length and adapting of the design and delivery method (for example, Howard and Melhuish, 2017; Wagner et al., 2020) • time management (create checklists, set alarms, reminders and notifications) • neurofeedback technology that allows for control of the computer by mind/attention alone using specialised tools	• access to contextually relevant knowledge • educational games and apps create excitement, promote active learning and help address students' engagement (Mango, 2015) • improving task completion and task management, and increasing independence • using the calendar tool to remind students of due dates of assignments or notify them of changes • conference tool is useful for meetings and reminders for task completions (Elmahdi et al., 2018) • personal data software (remembering important dates/tasks) (Fulton et al., 2012) • improving student attention, and enhancing academic and social skills (Beal and Rosenblym, 2018)

2.12.4 Empirical evidence of technology-based EFD improvement

The findings of Axelsson et al. (2016) are relevant in this context. Their study reports improved EF skills for pre-schoolers and older children using an iPad-based educational app game designed to improve cognitive capabilities. The study involved 36 pre-schoolers and older students (aged 3 to 7 and 8 to 14) with EF difficulties who were learning via teachable agent-based games. The participants were examined for their capability to sustain attention span and control (distractibility) by changing visual stimuli on the application. The results indicated that they were able to inhibit distraction and retain focus and attention during technology-based gameplay, with the educational game serving as a motivator in the presence of a teacher who scaffolded the cognitive capabilities of these students.

Wright et al. (2020) identify the role of technology in enhancing independence, organisation and time management skills in students with EFD. The study used a smartwatch as a tool, and findings indicated that students with autism and EFD executed their academic tasks independently with the help of learning guidelines they received via a smartwatch. This digital tool helped them keep track of their appointments and other weekly tasks. The technology also enabled self-monitoring and independence, as students entered their important schedule dates and appointment reminders themselves. Consequently, they could also concentrate on activities in a timely manner, and better complete their tasks. Overall, results show an improvement in EF skills, including planning, time management, organisation and general self-regulation.

Research also suggests that, along with effective teaching strategies, integrating technology with other activities in a small group should be done in parallel with teacher-mediated reflection (Agharuwhe and Nikechi, 2009). Panesi and Ferlino (2020) mention that this integrated approach would help to address metacognitive abilities (self-regulation, analysing actions and organisation) in young students and could help teachers design instructional strategies and learning paths for students, develop learning sessions and create increasingly difficult tasks. All these arrangements would require frequent teacher assistance, as well as their experienced guidance, until students could perform the activity independently (McCoy, 2019).

Any intervention oriented towards addressing EFD should also consider challenging students' EF skills in order to see improvements. Otero et al. (2014) explain that this involves a student moving beyond his comfort zone and existing competency level (Ericsson, 2009; Ericsson and Towne, 2010). This is akin to Vygotsky's concept of a ZPD, which is discussed in more detail in 2.14.1. Klingberg et al. (2005) and Bergman Nutley et al. (2011) explain that the increasing difficulty and challenge in computer games can push and motivate the student to go beyond that zone. For example, the WM training through CogMed software continually increases the difficulty level for the learner until they achieve the desired gains in EF skills.

Given the reservations about the use of technology mentioned above, it is significant that Panesi and Ferlino (2020) advocate the use of both traditional paper-and-pencil activities and contemporary digital tools (iPads and tablets) for improving EF skills. While relatively little attention has been paid to ascertaining the benefits of using both approaches together, the many advantages of integrating traditional, feasible, playful and engaging activities with the many affordances of digital technologies should not be ignored, and Panesi and Ferlino (2020) propose a mixed approach, involving both technological and teacher-mediated traditional instruction, and suggest that endorsing only applications and technology would be limiting.

In their systematic review, Gillespie et al. (2012) identify a significant relationship between the integration of technological tools and improvement in different cognitive functions, primarily attention, emotion, self-regulation, higher cognitive processes (planning, organising and time management) and memory. However, they propose that, for technology to be an effective intervention for EFD, there must be evidence of improvement in achievement and outcomes in different contexts, that is, both in classrooms and homes. It is important therefore to assess the perceptions of teachers and parents towards technology and the following section delineates this aspect.

2.13 Understanding teachers’ and parents’ perceptions about the use of technology

Incorporating teachers and families consistently into technological and other interventions is necessary to put research into practice (Weisberg et al., 2013; Burgener, 2019). Indeed, Pajares (1992, p. 308) asserts that "attention to teachers' beliefs and training can inform educational practice in ways that prevailing research agendas have not and cannot". Studies indicate that positive changes in the curriculum and its delivery rely upon policymakers’ ability to influence teachers’ beliefs in teaching children (Bradley et al., 2015; Regan et al., 2019), and Zuckerman et al. (2015) argue that there is a direct relationship between teachers’ perceptions and pedagogical practices, that is, how teachers decide to use a certain teaching method in the classroom. They also found that parents' beliefs play a central role in encouraging and facilitating their children's learning and academic success. Adopting devices across various settings, implementing individualised intervention programmes within school settings, and developing curriculum-based interventions all build EF skills in children (Zuckerman et al., 2015). However, while more research-based interventions are becoming available and accessible via small, affordable, personal devices, these require properly trained teachers and the support of parents in order to be effective (Alkahtani, 2013; Kirk et al., 2015).

Ozonoff and Cathcart (1998) classify three main features of effective treatments: firstly, the use of structured behavioural and educational approaches; secondly, training parents to implement the programme at home; and thirdly, enrolment in the treatment programme before the age of five years. The first of these depends on the teacher's effectiveness and their knowledge and beliefs to determine children's learning outcomes (Paro et al., 2009; Rapoport et al., 2016). Thus, an important dimension associated with teacher's effectiveness is adequate training to address EFD using technology, and studies suggests that context-specific teacher training can lead to significant improvements in EFD (Walk et al., 2018; Adebisi et al., 2015).

Ozonoff and Cathcart (1998) construct their classification by drawing on studies showing that home interventions can reduce feelings of stress and increase feelings of competence in students with EFD, an area in which parents play a significant role. In addition, Sills et al. (2016) found that parents' active participation is essential in helping children with EF difficulties to learn, and an earlier study by McConachie and Diggle (2007) found that they can even maintain the effectiveness of an intervention beyond the classroom. Many factors influence the success and delivery of both traditional and technological treatments, including parental attitudes, age, education and stress levels (Stahmer et al., 2011); however, Stahmer et al. (2011) suggest that positive parental expectations are of paramount importance when seeking to improve the learning outcomes and self-efficacy of children with EFD.

As a result of such findings, educational and health authorities are now promoting initiatives that encourage collaboration between parents and schools to better support students' learning and the development of EF skills (Zuckerman et al., 2015). Furthermore, several education-based groups in different countries are providing recommendations for parents to support their children's learning and academic achievement, helping them develop EF skills through technology and other modern interventions (Kirk et al., 2015). The success of such initiatives requires data about teachers' and parents' opinions to help enhance existing services and inform professionals, policymakers and planners about the effectiveness of technological interventions (Kirk et al., 2015; Kohler and Strain, 1999; Stahmer et al., 2011). However, despite extensive research on the use of technology in classrooms for students with EFD, Stehmer et al. (2011) note that there is limited research on family members and their influence in interventions, and few studies have explored teachers' and parents' perceptions of using technology for individuals with EFD (Endedijk et al., 2011). Therefore, this study's assessment of teachers' and parents' perceptions in the Saudi context will contribute to understanding of the use of technology to support EF skills development in these children, in both the Saudi context and internationally.

Having examined the literature relevant to this thesis, the final part of this chapter addresses the theoretical underpinnings of the current research study.

2.14 Theoretical perspective

The theoretical perspective underlying this study is the conceptualisation of scaffolding, the Zone of Proximal Development (ZPD) and the role of the 'more knowledgeable other' (MKO), originating from Lev Vygotsky's cognitive development theory. The theory works on the premise that learning is guided and mediated by social processes and interactions that leads to cognitive development of an individual (Cannella, 1993). It proposes that social interactions lead to cognitive development and that a child's learning is a form of social constructivism. The theory further describes cognitive functions as products of social interactions, that is, knowledge construction occurs as an interplay between students and others, with the interdependence between the student and social setting constituting a high-order learning process (Vygotsky, 1978a).

The ZPD is a metaphor which refers to the distance between an individual's ability to complete a task without help, and what they can do with support from an MKO (Vygotsky, 1978a). The role of the teacher as MKO is to encourage and help students reach higher levels in the zone using 'scaffolding' techniques that gradually fade based on students' needs in the learning process, such that the student becomes self-regulated when facilitated by the social environment (Ertmer and Simons, 2005). Through this process, the MKO (teachers, parents, peers and others) potentially direct students' thinking, interpretation, and social interaction, where the student internalises concepts based on their interpretations of the learning activity. Thus, knowledge development occurs through different stages of the ZPD and as a product of approaches adopted by an adult (Polly and Byker, 2020).

2.14.1 Conceptualising scaffolding and ZPD in light of Vygotsky's cognitive development theory

The ZPD provides a construct for how students develop skills and knowledge through scaffolding, modelling, coaching and situated learning, and there is wide-spread acceptance and application of the construct among educational researchers (Polly and Byker, 2020). Tharp and Gallimore (1988) elaborate four stages of the ZPD that are used by teachers progressively and in sequence. Stage 1 entails activities whereby performance is "other-assisted", that is, by MKOs in the given practice domain. The developmental goal is to move from "other-regulated" to "self-regulated”. Stage 2 is recognised as the "self-assisted" phase, as control is transferred to the student from the MKO, and the learning responsibility is self-supported. Stage 3 reflects the internalisation of learning and is manifested through consistent performance which requires no further assistance. Finally, in Stage 4, students adjust and modify their own actions in order to complete the task.

Margollis (2020) identifies this process as "assisted performance" through scaffolding, and the scaffolding concept is seen as a way of constructing the ZPD. As discussed above, the literature highlights three core principles of scaffolding: (a) contingency, (b) fading and (c) transfer of responsibility (Van de Pol et al., 2010); however, some researchers have viewed contingency as the most critical aspect of scaffolding (Van de Pol, 2012). In a teaching interaction, this refers to the adjustment of the support mechanism provided by the teachers according to the needs of the students, generally tailored to a slightly higher level than current performance. The other two factors, fading and transfer of responsibility, are interdependent and interrelated, and refer to the stages when support (the scaffold) is gradually withdrawn, and the student alone becomes responsible for performing the task in its entirety (Van de Pol et al., 2010; Rojas-Drummond et al., 2013).

Various scaffolding strategies guide the assisted performance attained through scaffolding, including modelling, feedback, instructing, questioning and cognitive structuring. Modelling entails creating specific classroom activities when a student's behaviour or lack of understanding demands it. An example of this would be modelling a cognitive process and setting out the steps through a think-aloud approach, including explaining the things being done. Knowledge is then internalised through repeated practice, and the student gradually assumes responsibility for further actions. Bardack and Obradović (2019) set out the scaffolding components and approaches used by teachers to address the three core areas of EF as follows:

- WM scaffolding involves teacher-oriented efforts to enhance students' abilities to memorise and update information on a given task through strategies (such as modelling using a reminder on a device), opportunities for practice (for example, discussions of the different steps for solving a long multiplication problem) or giving feedback (for example, encouraging a learner to use a different sequence or method to solve a problem).

- IC scaffolding techniques entail the teacher's effort to promote learners' control and impulsiveness abilities, (for example, by modelling, using turn-taking approaches, and rewarding good behaviour), practice opportunities (instructions on demonstrating active listening) and feedback (motivating them to raise their hands instead of interrupting by calling out).
- CF scaffolding entails teachers' strategies to develop students' flexibility in doing task activities (for example, modelling multiple ways of performing a task), practice opportunities (instructions/questions, such as explaining and asking about technology) or feedback (for example, approving their observations about things).
- Planning/organisation scaffolding involves teachers' ability to devise strategies to enable students to plan and organise their work (such as enabling them to use reminders of dates), practice opportunities (such as opportunities to organise tables or files) or specific feedback (such as complimenting them on how they organised the file binder).

These demonstrate the significance of strategies that facilitate the shift in responsibility to students, enabling them to improving their independence by applying and practising their EF skills through proper practice and response. The scaffolding strategies that were found to engage students in using EF skills in the school context could enable students' self-sufficiency in planning and organising their work, memorising, IC, and shifting abilities, thereby equipping them to better meet academic demands (Bardack and Obradović, 2019).

To return to the mechanism of the ZPD and scaffolding, Vygotsky's theory also proposes that ZPDs vary from learner to learner, even when they exhibit the same level of development (Vygotsky, 2011). Thus, some students at that level may require direct assistance, while others can learn with indirect assistance. This variation in the level of assistance and guidance required for each student mandates the need to determine sequential and differentiated teaching methodologies, mediating structures, and instructional design (Vygotsky, 2011; Rosa, 2014). Teachers' pedagogical strategies during scaffolding are therefore contingent upon student performance, and the decision to select a specific contingency condition should be closely calibrated to the student's current needs (Sottilare et al., 2014). Wood (2003) identifies three separate forms of contingency in this context: 'instructional contingency' (how to support learning), domain contingency (decision on what to teach next), and temporal contingency (when to intervene and help). Within the context of this study, this suggests that, if teachers assume a positive paradigm towards technology, and have adequate knowledge of students' strengths and needs, they will incorporate instructions accordingly.

Another interesting dimension to this is proactive scaffolding as elaborated by Vásquez Astudillo (2020), which entails the idea that teachers should pre-arrange the required content and support and should be astute enough to observe the executive functioning challenges of the student. Moreover, to help address the difficulties they should be prepared with multiple modes of engagement (which provide multiple forms of representation through various content formats) and also by designing multiple forms of action and demonstration. This aspect is particularly appropriate to the underlying study, as it will reveal the role teachers play in contributing to EF skills development through co-participation with the students with varying difficulties and different neurodevelopmental groups (Lin et al., 2013; Rodgers et al., 2016).

Given the evidence above, this study incorporates the concept of scaffolding and the ZPD in light of Vygotsky's theory to examine how the use of technology is modelled and used through scaffolding instructions, how scaffolding through technology (iPads/tablets) supports the development of the core EF skills, notably CF and WM, and how it enables students to overcome barriers to their academic accomplishment (Rose and Rose, 2007; Chen and Law, 2016). Incorporating these theoretical concepts reflects two critical dimensions. Firstly, the social development theory emphasises the role of social interaction in learning, and its underpinning concepts of scaffolding and ZPD. Secondly, that scaffolding is an effective strategy to facilitate EF skills development through technology-based instructions, integrated and used in a social system construct (Saudi Arabian schools) through varying means, and specifically for students with EF difficulties.

2.15 Conclusion

This chapter has provided a review of five key areas in relation to the research topic, beginning by reviewing technological initiatives in KSA and the different types of technological innovation in the country. It then explored the literature relating to EF in detail, identifying the core EF skill areas, how EFD is manifest in neurodevelopmental and acquired disorders, and how it affects students' academic development. The role teachers and parents play in addressing EFD and the effectiveness of existing interventions and support strategies were also considered, with a focus on the use of scaffolding as an instructional strategy in the classroom. The role of technology in addressing EFD was examined and the contributing factors and challenges in executing technology-based instructions to develop EF skills in students were discussed. The chapter concluded by introducing the key theoretical concepts which underpin this study, namely Vygotsky's social development theory, reinforcing the notion of scaffolding, and the ZPD, which provides a construct for how students develop skills and knowledge through scaffolding, modelling, coaching and situated learning. The following chapter explains the research methodology adopted in the study.

3 Chapter 3: Research Methodology

3.1 Chapter overview

This chapter presents the research methodology which underpins this study. It begins by identifying the underlying philosophical assumptions, with a specific focus on the researcher's epistemological, ontological and axiological positions. The choice of a qualitative multiple case study approach to address the research questions is also justified. The chapter goes on to describe the three case study schools and the research participants, comprising 15 teachers, six parents, and 11 students aged between 8 and 11 with EFD, who were identified via purposive sample. The data collection techniques, namely classroom observations, field notes and audio recordings, and semi-structured interviews, are discussed in detail. Then the measures taken to ensure the transparency and trustworthiness of the study and its findings are described, and the ethical considerations are highlighted and addressed. The chapter concludes by presenting the data analysis procedures adopted and justifying the choice of thematic analysis.

3.2 Philosophical orientation of the study

There is a universal acceptance of a system of ontological, epistemological, axiological and methodological assumptions in research, as these dimensions direct the researcher to adopt widely accepted research approaches (Feilzer, 2010). These aspects, known as research paradigms, provide the philosophical foundation of research (Killam, 2013) and address three distinct perspectives i.e. ontological (the nature of reality), epistemological (what can be known), and methodological (how findings will be generated). These dimensions collectively constitute a set of attitudes, values, beliefs, procedures and techniques, which set out a research framework able to formulate further theoretical explanations (Cane et al., 2012).

3.2.1 Epistemological and ontological stance

Philosophical orientations, specifically referring to epistemological and ontological stances, relate to the researcher's viewpoint for looking at the world, their perspectives about the importance of different things and events, and how things happen or work (Ratcliffe, 1983). Furthermore, Scotland (2012) explains that epistemology is concerned with the way a researcher is aiming to explore knowledge to reach reality. These paradigms or worldviews are broadly addressed in existing literature in terms of three philosophical stances: positivism, constructivism and pragmatism (Creswell, 2013; 2014). The present research is based on constructivist epistemology, which, as mentioned above, relates to "a way of understanding and explaining how we know what we know" (Crotty, 1998, p. 3). This epistemological position holds that truth and knowledge are integrated in a social context – that knowledge, can be co-constructed and is not isolated from human beings. Following this position, the underlying theoretical perspective of the research relates to the notion that exploration of a social phenomenon involves studying individuals' lived experiences and seeking to understanding the phenomenon through their perspective.

Adopting a constructivist epistemology involves undertaking an interpretivist approach; hence, the theoretical perspective of the underlying research is interpretivism. The intent of the interpretivist stance is to understand something in its given context (Denzin and Lincoln, 1994) and to "advance the knowledge base through interpretation of a social phenomenon in order to get shared meanings with others" (Bassey 1999, p. 44). Thus, the interpretivist approach involves exploring deep perspectives on a particular event of interest to obtain theoretical insights into possibilities and outcomes of future events. The interpretivist approach seeks in particular to understand the meanings people associate with their own social interactions (Al-Ababneh, 2020). Within the interpretivist approach, the shared meaning phenomenon is ensured by employing methodologies that facilitate an individual's opinions, motivations and reasoning, such as interviewing and participant observation. These are based on a subjective relationship between researcher and subject (Saunders et al., 2012); however, this aligns with a recognition that there could be numerous perspectives on social realities, and multiple meanings, constructed through subjective interpretivism and social interaction of individuals (Yin, 2009, 2013).

As the current research is intended to develop a perception of a social reality, i.e., to determine the role of technology in addressing EFD based on teachers' and parents' perspectives, it is interested in their views and lived experiences. A multiple case study approach was adopted for the present study to investigate the social phenomenon of how technology-based learning interactions take place in the mainstream setting of students with EFD, and, as a critical realist, the researcher incorporated relevant research methods, including observation and semi-structured interviews. Figure 3-1 shows the elements of the research process adopted for this study and demonstrates that the constructivist-interpretivist knowledge it contributes is the outcome of interactions of multiple elements between the researcher, participants (teachers, parents and the students observed) and the given context /environment (Creswell, 2013).

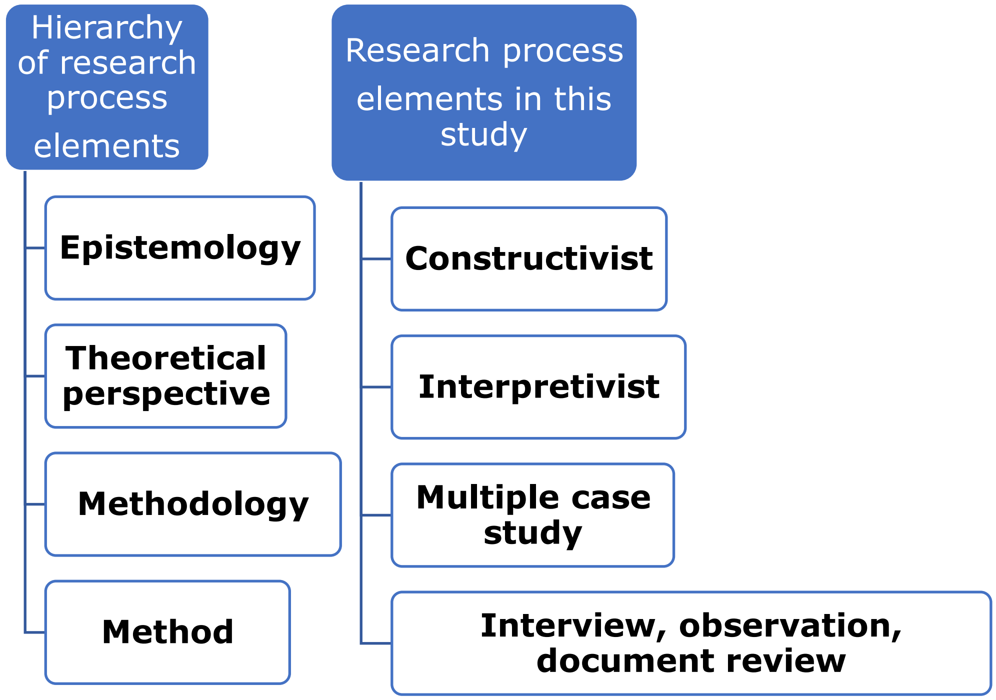

Figure 3-1: Hierarchy of research process elements. (Based on Crotty, 1998).

The following section reflects on the choice of qualitative methodology for the current research, specifically the use of multiple case studies.

3.3 Qualitative multiple case study methodology

As Sofaer (1999) asserts, when the intent of research revolves around assessing participants' perspectives, qualitative research offers meaningful foundations. Qualitative research also relates to describing collective concerns, interacting directly and developing a connection with study participants (Hamel et al., 1993). Therefore, qualitative research enables researchers to address questions about perspectives, experiences and opinions from the participant's standpoint and creates an avenue for constructing meaning related to real-life scenarios (Hammarberg et al., 2016).

Qualitative research assesses real-life systems using comprehensive data collection methods (Baskarada, 2014), and the case study approach attempts to understand persons, social communities and social processes as the subject of analysis (Houghton et al., 2015). The study of a case (or cases) in a real-life social context to explore an issue forms the mechanism of case study methodology (Yin et al., 2014); thus, a case study is a potential approach for a study that seeks to gather and generate meaningful data on a specific situation (Merriam, 2009). This notion fits the current study context, as the Saudi schools being studied function as real-life situations to yield meaningful data specific to the given setting.

Moreover, qualitative research offers an inductive pathway to develop concepts, insights and understandings into how people associate meaning and concepts with things and phenomena, via a flexible research design (Taylor et al., 2015). The lack of data on EFD in the Saudi context and how these difficulties are being addressed through the use of technological tools reinforced the need to obtain a detailed description of the phenomena related to the present study. In addition, adopting a qualitative approach was a practical choice as it allowed the researcher to develop a closeness with the study participants and gain valuable contextual information that could not be attained through less flexible quantitative and inferential methodologies (Mack, 2005).

However, it is important to mention that scholars have sometimes failed to appreciate the depth and complexity involved in qualitative research (Merriam and Tisdell, 2016), including in their choice of case study approach. As Ketokivi and Choi (2014) explain, either a single or multiple case study approach is selected, depending on the focus of analysis for the case in question. In multiple case study design, the researcher may select multiple sites to study an issue, or a single site to study multiple issues or to obtain multiple perspectives on the issue (Creswell and Poth, 2017) in order to facilitate a deep and complex investigation. As a result, the present study adopts the multiple case study approach, enabling the research topic and areas of concern to be evaluated using multiple cases to illustrate the problem.

According to Gottfert (2015), a case study approach facilitates the comprehensive examination of specific issues, and further allows for the analysis and review of specific cases. Considering data from multiple case studies enables the use of different lenses to frame the study phenomenon (Yin, 2017), and it also allows the logic of replication, as the researcher replicates the research procedure for each case in a different context (Creswell and Poth, 2017). Using multiple case studies in this research allowed the researcher to identify similarities and differences in the use of technology to address EFD across different schools, to determine variations in the perceptions and experiences of teachers and parents as regards EFD, as well as addressing the topics of instructional strategies and technological integration.

In addition, Yin (2011) reports that, when assessing behaviours, interactions, and emotions are central to study topics, a multiple case study is a valid form of inquiry to address a complex and broad range of topics. The dearth of research in the context of EFD at the institutional level in KSA meant it was necessary to conduct meaningful research that would potentially contribute to the existing research base. Therefore, a multiple case study approach involving different schools in KSA was used in the hope of contributing to the body of literature on EFD in the country. Applying this approach also allowed for the development of broader findings through multi-faceted investigations. Hence, there can be confidence in the study results, as using multiple cases enables the researcher to make rigorous efforts to investigate multiple events and associated issues in a natural environment that may not be quickly investigated and delineated at one time (Yin, 2014). In short, the adoption of the multiple case study approach allowed the researcher to select the most appropriate methodology to collect the relevant data, and to address the research questions and problems adequately. Having justified the use of the multiple case study methodology, the next section provides details of the study population and sampling.

3.4 Population and sampling

The present research selected three schools in Riyadh (the capital of Saudi Arabia) to explore EFD and how the use of technology may address these difficulties in different diagnostic groups (autism, ADHD and dyslexia). These schools, or *cases*, were located in different parts of Riyadh and were selected because of the characteristics of the participants (teachers and students), the population size in each school, and the accessibility and proximity of each selected case to the researcher. Riyadh was selected because its status as the seat of government and site of major ministries places it at the centre of educational reforms and developments, including those addressing special education needs. Additionally, Riyadh, as the capital and largest city, is diverse, and all Saudi subcultures can be found there. Moreover, considering the ease of access to authorities and participants, this city was the most feasible and convenient option for the researcher.

A purposive sampling technique is used when characteristics of units selected for inclusion in the sample align with the research rationale and can facilitate a rich description of the phenomenon in the research questions (Andrade, 2021). As a result, purposive sampling was used to select the cases for the present study, i.e., mainstream schools which included a range of students with SEN (to identify students with EFD from the wider population of the selected cases) and which were actively using technology to support these students' learning. After the schools were identified, formal contact was made with the school principals, the study participants were recruited via eligibility criteria, and informed consent was obtained. The students were identified by their class teachers, and their teachers and parents became the target population from which the target sample was selected.

Yin (2017) asserts that sample size in qualitative research should be sufficient to produce rich and detailed data, but it could range from just a few to up to 30 participants. The aim was to interview five teachers and two parents in each school, and to conduct observations on at least three children aged between 8 and 11 from each case study. Data regarding the participating teachers' and parents' awareness about EFD, the role of technology in addressing EFD, and the contribution it makes were collected via the teacher and parent interviews and the classroom observations. Saturation of findings was determined when no new patterns were produced while collecting additional data (Bloomberg and Volpe, 2018).

3.5 Description of the cases

The selected schools are all mainstream schools under the supervision of the MoE, with School 1 (S1) facilitating learning up to intermediate level (for children aged 11 to 12), School 2 (S2) providing elementary education (6 to 11) and School 3 (S3) a mainstream primary school (6 to 11). S1 was in an urban area, S2 in the centre of Riyadh, and S3 in the north of the city. Most people in the surrounding areas of each school are white-collar workers (companies, private sector) (S1); and Saudi nationals, government employees, and armed forces personnel (S2) (S3).

It is important to note that these schools are typical of state schools in KSA in that they offer single-sex education and only employ teachers of the same gender. This was compulsory in the state sector at the time the case study research was conducted, although policies to soften these requirements for very young children (aged 4 to 8) are being introduced as part of Vision 2030 (Arab News, 2019). Only boys' schools were selected, as the researcher is male and it would not have been considered appropriate, for cultural and religious reasons, for him to interview female teachers or observe female students. The implications of this constraint on the research are discussed in the concluding chapter (See Chapter 6).

The schools provide educational facilities and support services to students with special needs, including autistic, dyslexic and ADHD-affected students. The national curriculum as set by the Saudi MoE is followed in all three schools, with learning content created for an individualised educational programme. This plan contains elements based on the student's current level of study. The staff in each school are highly educated, with considerable experience teaching students with learning difficulties. The classrooms were equipped with both traditional (printable visual supports, calendars, schedules, pictures and flashcards, and chart papers) and technological educational facilities. Classrooms had smartboards, projectors and computers installed (S1); smartboards, iPads and a PC for instructors (S2); and smartboards, iPads (some provided by authorities and some students bringing their own), personal computers, and projectors (S3).

There were also resource rooms in S1 and S2, where some of the observation sessions were conducted. Students with challenging learning profiles were taken to a resource room for private learning sessions, practice, and the provision of supplementary support (Al Ghabr, 2021). For example, students with dyslexia were able to practice using multi-sensory strategies in a resource room, involving the simultaneous use of visual, auditory and kinaesthetic-tactile learning techniques, to optimise memory and learning of written language. Sometimes iPads, tablets and computer-aided instructions were also integrated to enable multi-sensory learning in resource rooms. Examples of this included spelling and vocabulary learning by playing a phonics application on the tablet and repeating the given word multiple times.

3.5.1 Participating teachers and parents

The principals identified teachers in each school who were using technology in the classroom to support students with learning difficulties. These teachers were then approached by the researcher, and a total of 15 (five from each school) agreed to participate in the study. They were all full-time, experienced teachers in mainstream school settings, with significant experience with SEN students. All the teachers were male, and their participation in the study was voluntary. The demographic details recorded for the teachers included their age, years of teaching experience with students with learning difficulties, and experience using technology, as these factors are key in determining student-teacher interaction and student development and achievements. Detailed demographic data for the teachers is provided in Chapter 4.

The teachers and parents were selected based on purposive sampling. The teachers were selected based on their experience teaching students with autism, dyslexia, or ADHD, and the inclusion criteria included their willingness to participate in interviews, to have their practice observed, and to consent to disclosing relevant information. The eligibility criteria for parents included:

(1) Their child is either autistic, dyslexic or has ADHD (determined profiles for research).

(2) Their child has been using technology (iPad/tablet) to overcome EF difficulties in school as well as at home.

(3) They know about the technology services being used at their child's school.

(4) They freely consent to their participation in the study.

The consent of the participating teachers and parents was obtained through consent letters. The consent form also outlined the inclusion criteria for both teacher and parent participants.

The parents were initially approached by the principal of their school and then by the researcher. Although the fathers of all the students identified by the teachers were invited to participate, only six (two from each school) participated in the case studies. Due to the cultural and religious restrictions on gender-mixing mentioned above, only fathers were invited to participate in the study. The implications of this for the study are also discussed in Chapter 6. The two fathers from S1 had an autistic child of 10 and a dyslexic child of 8, respectively, those from S2 had an autistic child of 8 enrolled in Grade 4 and a dyslexic son of 7 with poor communication skills, respectively. The two fathers from S3 had a child with ADHD aged 7 and an autistic son of 12, respectively. Further demographic details about these participants are provided in Chapter 4. The third student who participated in this study was dyslexic. His father reported that he had difficulty in starting and finishing his tasks. He also mentioned that he often received complaints from teachers about how distracted he was in class, and that he would pay very little attention to instructions. He also reported that his son would get frustrated when he forced him to do reading and writing practice. However, he was not sure of the relationship of these issues with his reading and writing difficulties and dyslexia.

3.5.2 Observed students

A total of 11 students with a variety of ages and neurological conditions were selected for observation across the three schools. These students were initially identified by their class teachers, and permission was then sought from their parents to include them in the study. The ethical issues involved in obtaining consent for these students’ participation is discussed in 3.8. In some cases, fathers consented to their sons being part of the study, but were not available to be interviewed themselves; hence the difference between the number of participant students and parents.

For Case 1 (S1), three students were selected for observation, aged between 9 and 11, two with autism, one of whom also had ADHD, and one with dyslexia. For Case 2 (S2), one student with autism, two students with ADHD, and one with dyslexia were selected. From S3, four students aged between 8 and 11 were observed, one with autism, one with ADHD, and two with dyslexia. Table 3-1 shows these students ages, neurological groups, and their perceived EFDs.

Table 3-1: Characteristics of students selected for observation

School	Age	Neurodevelopmental group	Description of perceived EFD (as reported by parents, teachers or observed by the researcher)
S1	9	Autism	His father reported that his son exhibited learning difficulties, hyperactivity, and lack of attention, as well as challenging behaviour. He further reported weak memory in his son, difficulties in learning tasks, a lack of IC, and continual switching from task to task.
	10	autism (with ADHD)	His father reported his struggle with his autistic son. The noticeable characteristics he observed in his child included a lack of focus on a task when alone, being reluctant to take the initiative, restlessness, and switching from one step to another without completing the task. He said that his child constantly required external help to complete his work, as he was easily distracted by any sounds in his surroundings.
	11	Dyslexia	His father reported that he had difficulty in starting and finishing his tasks. He also mentioned that he often received complaints from teachers about how distracted he was in class, and that he would pay very little attention to instructions. He also reported that his son would get frustrated when he forced him to do reading and writing practice. However, he was not sure of the relationship of these issues with his reading and writing difficulties and dyslexia.
	8	Autism	His father reported his son as being an autistic student with many challenges, some of which include a lack of focus and short attention duration, and losing interest rapidly. The inability to control his impulses leads him to switch from one task to another without completing the first. It is also a significant challenge for teachers and parents to get him to focus on tasks which are not appealing to him.
	8	Dyslexia	His father reported his child has poor communication skills. He further elaborated that this child struggles with learning and often has trouble

S2			starting and finishing his work. Memorising is another challenge faced by the child, who also exhibits frustration that upsets him for long periods.
	9	ADHD	The class teachers reported that these students move around constantly, fiddle with objects, and are seen to talk excessively. They are inattentive and lack focus in long lessons, particularly in repetitive activities that lack creativity. These challenges limit their ability to perform academically. This is evident in their confidence levels, as exhibited by reduced participation with their peers.
	10	ADHD	
S3	11	Autism	According to his father, he experiences problems in retaining information. He exhibits stubborn behaviour and moves quickly from one task to another. His lack of attention and weak memory affect his academic performance, as demonstrated in his weaker reading, spelling and comprehension.
	8	ADHD	According to his father, he exhibits learning and behavioural difficulties, and an inability to remain calm due to his hyperactivity. He also poses a challenge during teaching at home. The inability of his parents to sustain his focus on a learning activity makes it difficult for them to make him memorise or pay attention, and remain engaged during lesson instructions. He loses interest and becomes bored and is easily distracted by sounds in his surroundings. Once distracted, he cannot control himself to stay in one place during learning sessions.
	8	Dyslexia	The teachers reported that the first student with dyslexia would demonstrate frustration and distraction when trying to read and was reported to skip parts of the texts while reading. He occasionally misbehaved, showed disinterest, and refused to read. The other student was observed constantly interrupting other students during the session. Both appeared to listen to the instructions from the teacher, but when questions were asked, they did not remember anything.
	10	Dyslexia	

Having described the study participants, the following section sets out the data collection methods.

3.6 Data collection methods

Baxtor and Jack (2008) state that rigorous qualitative research presents researchers with opportunities to undertake data collection from multiple sources to explore and describe the underlying phenomenon. In addition, Lodico et al. (2010) report that, in order to produce relevant, in-depth data, case study methodology usually utilises observations, interviews, and document analysis as data collection techniques. Therefore, different data collection sources were utilised for the current study, namely, observation and field notes and semi-structured interviews. A detailed elaboration of these sources is given below.

3.6.1 Observation

Using the observational method in qualitative research is important for discovering and ascertaining the details of complex interactions. Observational data can be integrated as an auxiliary or confirmatory method in order to corroborate the research findings (Jamshed, 2014). Moreover, when deep and rich descriptions of findings are required, the observational approach provides an opportunity to enrich the information collected through other methods, such as interviews. As Bush (2012) explains, it enables the observer to learn about things that respondents are unaware of or may not be willing to discuss during interviews. It also allows the researcher to develop a direct interpretation of the phenomenon (behaviours and interactions) in question rather than solely relying on participants' viewpoints and perceptions as expressed through semi-structured interviews (Bloomberg and Volpe, 2018). Thus, the use of observation aligns with the constructivist-interpretivist approach adopted in the current study by enhancing the primary information collected through semi-structured interviews (Creswell, 2013) and generating a better understanding of the research outcomes (Newby, 2014).

Observation is considered appropriate when data collection is focused on assessing interactions and relationships and recording behaviour, interactions and conversations. In this study, data collected through direct observation was used to provide a detailed account of how technology (iPads/tablets) was used, and how teachers were managing students' EFD along with other techniques and instructions. The ultimate objective of conducting observation prior to the semi-structured interviews was to allow the study to obtain a more detailed description of specific contributions, characteristics and teaching methods in a classroom setting (Zohrabi, 2013). This approach also avoids the subjectivity dimension in specific social actions observed (Morgan et al., 2015; Spradley, 2016).

In order to systematically observe each teacher's teaching method, non-participant observation was incorporated. Non-participant observation is an unobtrusive means of observing study participants without interaction (Jorgensen, 2015; Spradley, 2016). The intent in choosing this form of observation was to assess participants' social behaviour by recording what was observed, that is, teachers' and students' interactions, to see how teachers help children to use technology to overcome their EFD. In addition to the input from interviews, it was hoped that naturalistic observation of how teachers scaffolded technology to help students develop their EF skills would help determine the teacher's role and expertise. It was also hoped that the students' performance would reveal their improvement pattern.

Detailed field notes on participants were made throughout these observations. Taking field notes enables multiple insights to be collected during fieldwork (Jorgensen, 2015; Morgan et al., 2015), and the researcher's field notes recorded both observations and reflections that later enabled a deeper insight into written transcripts and subsequent review. The observation sessions took place at different intervals and on different occasions throughout the observation schedule, and each activity was documented in a reflective journal. Each observation session recorded four essential aspects, namely, i) teacher-student interactions, ii) the teacher's use of technology with the students, iii) the teacher's proficiency and expertise in using the technology, and iv) the use of group instructions and individualised instruction sessions. A more reflective style of note taking included recording classroom activities in detail, including timing, the layout of classrooms, teacher-student interactions, and the strategies used while employing technology and scaffolding activities. In addition, students were observed for their involvement with instruction, use of technology, behaviour and issues determining their EFD based on their diagnostic group.

Six observation sessions of approximately 45 minutes in each school were conducted using a field notes observational protocol to record different classroom activities and interactions (See Appendix 5). An attentive approach was adopted to record early impressions and activities in the given classroom context, as Merriam (2009) stresses the need for observers to be watchful for minor details in early observation sessions that will help determine comparison with later patterns of observation. Intervals were incorporated between each activity and session, so, for example, a student was first observed for 30 seconds, before being observed during teacher interaction for another recording interval of 30 seconds.

Following the observations, semi-structured interviews were conducted individually with teachers and parents.

3.6.2 Semi-structured interviews

As Patton (2015) explains, using an interview approach allows the researcher to delve into the other person's perspective and obtain information related to a specific issue that cannot be observed directly. Interviews offer versatile meanings and interpretations, allowing the researcher to consider validity by controlling for bias, and establishing trust and the truthfulness of data (Galletta, 2013; Brinkmann, 2014). Scholars have long valued direct or face-to-face interviews for the naturalistic interaction they facilitate and the depth of connection a researcher can develop with the participant relative to other modes of interviewing and interacting in research (Gillham, 2005). Indeed, Novick (2008, p. 397) terms this approach the "gold standard" of qualitative data collection. Furthermore, Sietz (2016) lists multiple attributes of direct interviews that allow better interaction for data collection, including physical proximity, in addition to the assessment of non-verbal cues and other expressions that add to data collection rapport. As a result, face-to-face interviews are considered as an essential resource for engaging with an issue of concern (Rapley, 2001).

The continuum of interview structures varies from highly structured to an informal conversational style. Yin (2018) states that the approach between these is the semi-structured interview, which draws on both standardised and informal questions to elicit responses. This semi-structured approach allows maximum flexibility and freedom to explore by putting participants at ease, but also entails some standardisation of questions (Hofisi et al., 2014). The interactional aspect of semi-structured interviews also allows a visual encounter with the respondents and the generation of non-verbal data. This includes body language, facial expressions, and interview settings in general (Irvine et al., 2013). The advantages offered by semi-structured interviews encourage the researcher to establish an organised conversation directed at generating new information via interactivity. It also allows participants to share in the process and discuss significant concerns (Kallio et al., 2016).

Consistent with the underlying needs of the study, the perceptions and attitudes of teachers and parents were examined through semi-structured interviews to generate data to support a clearer measurement of respondents' views (Pathak and Intratat, 2016). They also helped the researcher obtain deeper insights into the concepts that emerged from note taking during the observations and to correlate the findings of both methods. The focus of the semi-structured interviews was to generate rich description, considering the three research questions. The primary focus was on the role of technology in addressing EFD through teachers and parents' perspectives. The questions also focused on exploring teachers' and parents' perceptions and knowledge about EFD, as well as what contributions they perceived technology as making to the overall learning of students with EFD.

Scholarly evidence suggests that, for qualitative research to reach findings saturation, a total of 10-15 interviews are required (Mason, 2010). However, this does not prevent the researcher from adding more interview participants until the saturation point is reached (Marshell et al., 2013), with this being reached when no new information is obtained through data collection (Nelson, 2017; Weller et al., 2018). In this study, interviews were conducted with 15 teachers and six parents in total from the three schools once their verbal agreement to participate had been obtained. This sample size was sufficient to facilitate a detailed analysis and investigation of the study phenomena. However, in order to identify the saturation point, the researcher monitored the participants' responses to check whether there was still an opportunity to obtain new information (Saunders et al., 2018). Convenient dates, times and venues for each interview were agreed between the researcher and participants from each school, with quiet settings preferred in order to facilitate thoughtful, high-quality interview sessions (Maxwell, 2013). The interviews were conducted in Arabic. They were then translated for further data analysis through back translation, or the reverse technique, which is explained below (See3.9.1.2).

Despite the advantages of naturalistic in-person interaction during interviews (Gillham, 2005), the researcher had to conduct some of the interviews online owing to the Covid-19 pandemic and the associated national lockdowns, which closed the schools. For this reason, the majority of the interviews were conducted using Microsoft Teams, or, at the participant's request, on Zoom. Scholars have acknowledged the benefits of using different modes for interviews, and Addo (2020) and Archibald et al. (2019) describe virtual interview methods as providing a positive experience to participants. They cite the convenience of an online medium and greater ease in discussing sensitive topics than would be possible in face-to-face interviews. In this study, the use of Microsoft Teams for some participants also meant that interviews could be video-recorded. However, despite the positive attributes reported in the literature, technological issues occasionally meant that the researcher could not collect all of the required data at one time and was obliged to reschedule.

An interview protocol was used to conduct the interview session (See Appendix 7), functioning as a guide through a list of predefined questions. These were developed in light of the three research questions and divided into three sections, one for each question. The semi-structured protocol facilitated and encouraged participants to give purposeful and detailed responses in conversations (Yin, 2018). Keeping the protocol questions as a guide, the researcher also asked open-ended and follow-up questions for clarification of the responses and perceptions of participants regarding their experiences. In addition, probing questions were asked using the critical incident technique (Flanagan, 1954) to encourage participants to discuss situations where they had experienced the effects of students' specific EFDs. For example, the researcher asked parents if they could recall times when they had experienced their child's forgetfulness and weak memory. Similarly, teachers were asked if they could recount any specific situations when they had experienced a lack of attention and focus in specific students.

Table 3-2 below summarises the different data sources employed to address the research questions:

Table 3-2: Research questions and data sources

Research Questions	**Data Collection Methods**
To what extent are parents and teachers aware of the concept of EFD in Saudi schools?	Semi-structured interviews (transcripts, reflective journals, bracketed field notes)
How is technology being used to support students with EFD in Saudi schools?	Semi-structured interviews (transcripts, reflective journals, bracketed notes) Classroom observation (field notes, observation protocol)
What are the main contributions that parents and teachers see technology making to the learning of students with EFD?	Semi-structured interviews (transcripts, reflective journals, bracketed notes) Classroom observation (field notes, observation protocol)

Having explained the data collection methods utilised, the following section provides a detailed view of the trustworthiness and transparency of the present study.

3.7 Evidence of transparency and trustworthiness

In qualitative research, the researcher is the primary data collector, and the data's qualification for further interpretation is dependent on what has been observed during interaction with the study participants (Zinyama et al., 2022). As a result of the researcher's engagement in meaning-making, qualitative research methodologies are often criticised for their subjectivity (Hesse-Beiber and Leavy, 2010). In this respect, Muzari et al. (2022) emphasise that the researcher should enable the participants to fully engage with the study phenomena in order to enhance the trustworthiness, credibility and transparency of the data findings.

The validity of qualitative research represents more of "a goal than a product" (Kaplan and Maxwell, 2005, p. 105), and carries significant weight in ensuring the characteristics and strength of a qualitative study. The trustworthiness of qualitative research is related to evaluating a study's general worth and the quality of the evidence involved (Lincoln and Guba, 1985). According to McInnes et al. (2017), establishing trustworthiness in qualitative research requires the use of proper protocols and procedures during data gathering and analysis. In terms of this study, Kothari et al. (2017) state that a multiple case study design facilitates multiple opportunities for the researcher to assess multiple points of evidence and compare and confirm data within and across different cases. Yin (2017) also supports using multiple sources of data, but points out that this has the potential to overwhelm the researcher due to the quantity of data generated, therefore precise procedures to maintain the study's quality and reliability are required.

In addition, assessing the use of technology to address EFD in different diagnostic groups requires a research approach which can encompass multiple realities and factors. Nilmanat and Kurniawan (2021) report that, if rigorous research procedures and comprehensive methodological foundations are maintained, a qualitative case study approach could be one of the best choices in this context. Nowell et al. (2017) add that, for qualitative research to be classified as trustworthy, the researcher should guarantee that the data analysis is precise, consistent, and exhaustive by recording, systematising and elaborating the techniques of analysis in sufficient detail for the reader to determine the credibility of the process as a whole.

Thus, in order to ensure trustworthiness, it is essential to develop rigorous strategies. Baxter and Jack (2008) emphasise the transparent presentation of rigour, adding that qualitative case studies' conductive nature facilitates trustworthiness and rigour. However, they also note that the researcher needs to spend adequate time observing events and relevant aspects to enhance the quality of the data generated. This active involvement reduces misinformation and biased data. Additionally, spending sufficient time on observation facilitates meaningful engagement to discover the interactions, interlinkages and connections of different elements in the given case's context and enhances the credibility of the research.

3.7.1 Credibility

Credibility is one of the principal attributes in ensuring research trustworthiness, as it reflects data confidence and truth (Saldana, 2021), and is a parallel aspect of internal validity (Abdalla et al., 2018). The element of credibility in this research has been maintained by spending sufficient time on observation sessions, peer debriefing, and thorough, well-organised, data collection methods. In addition, the use of well-established research methods using multiple sources of data collection through rigorous qualitative practice and purposive sampling to obtain experiences and perceptions from the right participants have enabled credibility.

3.7.1.1 Peer debriefing

Peer debriefing, in which professional peers are engaged in the data analysis and discussion process, is considered essential in qualitative research, as it enables continuous quality checking throughout the process rather than just at the end (Lodico et al., 2010). Peer debriefing is a collaborative activity to garner bias-free analysis of data collected from participants; hence, its ultimate goal is not to reach any agreement, but to challenge and question the research assumptions and to be vigilant regarding the researcher's bias and subjectivity in interpretation (Henry, 2015).

During data collection for this study, the researcher played not just the role of researcher, but also those of interviewer and facilitator, which increased the likelihood of bias. Hence, peer debriefing through analytical probing allowed the researcher to remove taken-for-granted biases, validate the data findings, and establish validity for the case studies (Nilmanat and Kurniawan, 2021). To this end, the researcher sought assistance from colleagues outside the study context who are research professionals and have a general understanding of the processes whereby findings are analysed.

3.7.2 Confirmability

Conclusions in qualitative studies are a function of more than one type of data source (Yin, 2015). Hence, multiple data sources indicate confirmability, with a preference for the objectivity of data findings (Shenton, 2004). In addition, Patten and Newhart (2017) state that addressing the tendency towards researcher bias (intentional and unintentional) is essential in determining confirmability, so bracketing was employed by the researcher (Tufford and Newman, 2010). As Baksh (2018) explains, bracketing refers to the practice of keeping aside personal or implicit assumptions, and personal thoughts and beliefs that may undermine the quality of the research findings, and it requires the researcher to be aware of their ontology. Bracketing is dependent on the researcher's mindfulness throughout the different stages of research and the suspension of personal judgements when seeking to understand participants' subjective responses. In this study, the assistance of non-participating peers was utilised to reflect on the researcher's previous knowledge and beliefs in order to produce a more insightful understanding of others.

3.7.3 Transferability

Transferability determines the generalisation and applicability of the research findings, similarities and patterns (Burchett et al., 2013) to other different contexts or situations (Merriam, 1998), and accounts for the external validity of the research (Abdalla et al., 2018). According to Bloomberg and Volpe (2016), transferability of research occurs when the research's conclusion is useful and aligns to the interest of others across similar contexts. The results of this study were obtained from three different Saudi schools and from a versatile group of participants with different demographics, levels of technological proficiency, and experience with students who have EFD. In addition, the observation sessions examined different instructional strategies and uses of technology, and the findings and results are therefore more likely to be applicable to a range of other school contexts within KSA.

Another aspect that determines the transferability of the study is determining the exact parameters used therein, i.e., the number of schools targeted, the criteria for study participants, the number of participants, the data collection methods, and the time involved for data collection. Details of the three targeted schools, the criteria for the teachers' and parents' participation, and the number of participants from each school are set out above (See 3.5.13.5), and the data collection methods (semi-structured interviews and observation) and the time involved for data collection (three months) are described in detail in 3.6, and this chapter as a whole describes a detailed process through which to delineate the relevance of the research findings. All these aspects determine the transferability by generating quality information to support the findings' applicability to other external contexts, namely to other specific educational contexts and schools in Saudi Arabia.

Transferability also relates to the external confirmability of the study findings (Lincoln and Guba, 1985). Once the present research is complete, readers can evaluate it for themselves and analyse the findings relevant to their own classroom or school contexts. The multiple case study analysis provides a point of further assessment and comparison for teachers, policy makers and future researchers to identify the contextual evidence obtained from different schools, and to apply the information in related contexts. Although the study findings do not produce any statistical generalisations or implications, they still represent a positive contribution to the existing literature on EFD, to of teachers and parents awareness of EFD, and our understanding of the role of technology in addressing EFD and its contribution to student learning overall.

3.7.4 Dependability

Dependability relates to the reliability of the study results and findings and defines their consistency. The study data categories (raw data, processed data, and interview protocols), were carefully recorded, translated, and transcribed to generate adequate information to answer the research questions. The descriptive notes obtained from interview sessions and observations were sufficiently comprehensive to produce feasible interpretations and conclusions consistent with the data findings. Another critical factor in maintaining the trustworthiness of qualitative research is the need to be watchful for disconfirming and deviant cases, that is, findings and opinions that deviate from the main body of evidence (Creswell and Clark, 2017). Therefore, the resultant outlying information was removed and not evaluated while constructing data themes.

The researcher's personal and professional role kept him aware of the need to ensure objectivity and remain neutral during data collection and analysis. Therefore, in order to enhance the dependability of the data collection and analysis, he kept a reflective journal to avoid potential bias regarding the participants' responses and to increase the likelihood of internal consistency.

Reflexivity was also employed as a technique for preventing personal bias on the researcher's part, using the bracketing approach detailed above (See 3.7.1). The rule of reflexivity set out by Hertz (1997) was implemented, with constant scrutiny of "what I know" and "how I know it" through the constant detachment of pre-conceived ideas and concepts about EFD and the use of technology. The use of detailed note taking at intervals also helped the researcher to keep track of his own biases and personal thoughts and values.

Additionally, the researcher focused on prompting, probing and encouraging participants to express their viewpoints and opinions, about their own attitudes and capabilities, about children's behaviour and their specific learning difficulties, and the way technology is used to support them. Doing so raised a number of ethical issues, so the following section addresses the key ethical considerations which affect the research.

3.8 Ethical considerations

An ethical research framework is vital for the dignity of the research process and for protecting research subjects and information (Walliman, 2017). The potential vulnerability of research participants requires a code of conduct to protect their well-being in sensitive aspects of the research, as well as protecting the findings' credibility, dependability and transferability (Mockler, 2014). Applied research ethics have established rules and guidelines to which researchers should adhere, prior to and throughout the course of the research.

The purpose of research can also be better fulfilled by following the norms and appropriate values in all stages (Bell et al., 2018).

In the present study, the guidelines for good working research practices prescribed by the University of Nottingham (UoN) and the British Educational Research Association (BERA) (2018) were followed strictly throughout the research process, and the research was approved by the School of Education's Research Ethics Committee at the UoN prior to the commencement of research process (See Appendix 3).

According to Oliver (2010), it is imperative to guarantee the protection of information related to the participants prior to beginning the research process. In doing so, the researcher and participant establish honesty and trust. Due consideration for advocacy and respondent data and information safety (Alderson and Morrow, 2020) was therefore critical in this study. The researcher ensured that sensitive information about participants, as well as their anonymity, confidentiality and privacy were protected. Thus, pseudonyms were assigned to the participating teachers and parents to ensure the anonymity of their responses. In addition, the data collected through both observations and interviews (filed notes, transcripts, audio recordings) was kept in a locked and secure site. Meanwhile, audio recordings and digital copies of some reflective journals and field notes were transferred to an external hard drive that was encrypted and kept in the researcher's personal locker. The audio recordings were deleted once the data collection stage had been completed to further safeguard participants' privacy.

According to BERA's (2018) ethical guidelines, the intent of the research should be communicated to the participants, both to inform them of the potential benefits for all parties to which the research might lead and to obtain their informed consent. Equally, it is essential for research to promote the well-being of its participants and avoid any deception or bias (Miller et al., 2012). In this study, the authorities and administration at the selected cases (schools) were informed of the study's nature and scope directly, and the researcher also communicated with them regarding the research rationale and expectations, both via a detailed letter and in-person discussion. The school authorities were first contacted by email, followed by a face-to-face meeting, and then a telephone call to schedule the meetings to select teachers to approach and request their voluntary participation.

Teachers and parents were given the choice to participate in or leave the research process at any time, especially if they felt any infringement on their dignity or doubted the privacy of the process (Resnik, 2011), and were under no duress or obligation. The research was explained to them before the interview sessions, and they were asked to read the participant information sheet carefully, as this set out the overall research rationale (See Appendix 6). Teachers and parents were also asked to provide informed consent to be interviewed by completing the participant consent form (See Appendix 4). By signing, they also gave permission for their responses to be recorded, either audio or video recording (for online interviews).

As this research concerns vulnerable young children (those with EFD), it was crucial to obtain appropriate consent to their involvement in the study before observations were conducted. According to the BERA guidelines:

> In the case of participants whose capacity, age or other vulnerable circumstance may limit the extent to which they can be expected to understand or agree voluntarily to participate, researchers should fully explore ways in which they can be supported to participate with assent in the research. In such circumstances, researchers should also seek the collaboration and approval of those responsible for such participants. (BERA, 2018, p. 15)

As a result, the parents of the students were asked to explain what the research involved to their children, to the fullest extent possible, to establish whether they had any objections, and then to consent (or not) on their behalf. In addition, to ensure the integrity of the research and that ethical stipulations were being met, the researcher sought cooperation from the management of the target schools, thus making the process more of an enhanced collaborative effort (Bell and Bryman, 2007).

The following section presents the details of thematic analysis and coding as a data analysis approach.

3.9 Data analysis and coding

Data analysis is the systematic process of subjectively interpreting data content through coding, i.e., utilising workable themes and patterns toward emerging conclusions (Hsieh and Shannon, 2005), and, according to Creswell (2013) it entails organising, familiarising oneself with, reading, assigning codes to and interpreting data findings. As Cypress (2018) notes qualitative findings are a set of complex and varied data obtained through multiple modes, in this case, field notes, reflective memos, audio recordings and interview transcriptions, and these require expert handling to put them in a consistent structure for comprehensive analysis. Therefore, scholars such as Braun and Clarke (2019) have suggested that the coding and theme generation of the data findings should be directed by the content of the data, and that, due to the diversity of data collected and the underlying complexity of the information produced, thematic analysis offers a flexible solution to produce results from such data.

3.9.1 Thematic analysis

Thematic analysis is an inductive approach to exploring emerging themes within data, and it is the most widely-used analysis strategy for qualitative studies (Wildemuth, 2016). It helps in the interpretation of data through the reduction of that data, and, according to Castleberry and Nolen (2018), thematic analysis of responses obtained through open-ended surveys facilitates the exploration of concepts that cannot be attained by quantitative measures. Maguire and Delahunt (2017) also advocate thematic analysis as one of the most effective approaches in the social sciences, as it offers a clear and usable framework for analysis; however, efforts to maintain transparency in qualitative procedures and the trustworthiness of the process are required (See 3.7 for details of the measures adopted to address this in this study).

As the researcher requires an immersive reading of data to establish meaning and patterns, thematic analysis was employed for analysis of this study's findings. In addition, obtaining a deeper insight into the responses and data from observation sessions entails coding the interview responses using an inductive approach, which is primarily based on descriptive and exploratory orientation (Guest et al., 2020). Hays and McKibben (2020) also propose that an inductive approach to thematic analysis in qualitative research is suitable, as it develops the generalisability of implications and helps develop appropriate interpretations of the study phenomenon.

Braun and Clarke (2006) identify a number of distinct phases of data analysis, which were followed in this study. These are presented in Table 3-3 and described in more detail below.

Table 3-3 : Phases of data analysis by Braun and Clarke (2006)

No	Phase	Description
1	Familiarisation with the data	Transcribing data
2	Generating initial codes	Coding interesting features of the data in a systematic fashion
3	Searching for themes	Collating codes into potential themes
4	Reviewing themes	Checking if the themes work in relation to the coded extracts
5	Defining and naming themes	Ongoing analysis to refine the specifics of each theme
6	Producing the report	The final opportunity for analysis

3.9.1.1 Phase 1: Familiarisation with the data

In order to familiarise oneself with the breadth and depth of the data's content, Braun and Clarke (2006) recommend a thorough review of that data. Each data source in this study (memos, field notes, interview transcriptions and personal journals), was reviewed systematically to establish iterative ideas leading to themes in the data. Braun and Clarke (2006) stress that this phase enables the identification of central ideas for themes. Moreover, this phase allowed the researcher to take refined memos and notes to develop codes for naming themes. The researcher also ensured that quality attributes were maintained. This included ensuring the validity and reliability of all data sources by verifying translated transcriptions, including through member checking by taking feedback from teacher participants, as set out below.

3.9.1.2 Transcription and translation

According to Abfalter et al. (2020), translating data collected through qualitative methods into another language is a crucial step, an artistic technique, and a prerequisite for research, which requires exceptional expertise. Adding to this, Behr (2017) also stresses the element of rigour in translating data from one language to another. In order to develop accurate transcriptions of the interview data (from Arabic to English), the researcher dedicated considerable time to listening to and transcribing interviews and reviewing transcripts to ascertain whether anything had been missed or required adjustment. The interviews conducted online were recorded and then transcribed by the researcher.

As Al-Amer et al. (2015) note, back translation or reverse translation is an effective measure that involves retranslating the data content from the target language (English) back to the source language (Arabic) through an expert bilingual translator. The subsequent review of this back translation supports quality assurance. To address this, the researcher translated the interviews from Arabic to English, and then a specialist translator was asked to translate the English transcripts back to Arabic in order to assess the quality of the first translation and to determine if any unconscious bias may have existed within it (Patten and Newhart, 2017).

As McGrath et al. (2019) state, transcription is a crucial step, as it allows any misinterpretations and possible biases based on those misconstructions to be ruled out. The transcriptions of the translated interviews were securely protected in an encrypted file and then shared electronically with all participants to review and highlight any misinterpretations The participants who read the transcriptions reported no such problems. This phase also allowed the researcher to become more familiar with the data and create meaning for the thick descriptions.

3.9.1.3 Phase 2: Generating initial codes

The coding process entails making annotations and assigning words, phrases or letters related to the research questions (Merriam and Tisdell, 2015). In order to develop initial codes, the researcher disassembled and categorised the data in light of the three research questions to identify any reoccurring patterns. As the interview protocol was divided into separate sections for each research question, repeated comments and concepts were given the same colour code in each section. Yin (2016) suggests categorising the data from each source in an organised way. Thus, interview transcripts, field notes and personal reflections on observations were all arranged as notes. The initial process of going through these sources systematically established Level 1 codes of repetitive terms in each transcript. The revision of these Level 1 codes further established broader Level 2 codes.

Moreover, to cross-assess the initial categories of codes, the researcher re-examined the transcripts, bracketed reflective notes, field notes (transcripts) and audio recordings of interviews and observations to assess the patterns attributed to each research question. Hence, the prominent themes identified were relevant and corresponded to each research question. The initial category codes made up the major themes, with others forming subthemes.

3.9.1.4 Phases 3-4: Searching for and reviewing themes

During this phase, similar initial codes, and codes containing the same content were grouped. Yin (2015) identifies this phase as reassembling abstract concepts to establish pattern matching and comparison, and it requires a deeper comprehension of the data, since comparable codes are used to identify themes and subthemes, providing the foundation for a narrative of the study's results (Creswell and Poth, 2018). The researcher reread the developed themes to see whether they were compatible with the dataset and evaluated them to identify any inconsistencies.

3.9.1.5 Phase 5: Defining and naming themes

This phase enables clear thematic evidence to be obtained. The researcher defined the themes developed in the previous phases using descriptive terms and looked to further refine the titles for each theme for presentation in the final version of the analysis. This entailed a detailed analysis of each theme, and writing detailed descriptions of interpretations of each theme, in light of the different data types obtained during data collection. By the end of this phase, the researcher was able to establish links between each theme under the respective research questions. For example, a common theme emerging across all cases was ‘balanced use of traditional and technological tools to address EFD’. This theme identified teachers’ and parents’ perspectives on using both approaches in addressing EFD in students. This theme relates to the primary research question of the study: How is technology being used to support students with EFD in Saudi schools?

3.9.1.6 Phase 6: Producing the report

The final phase of the data analysis was to produce a final and comprehensive document and analysis for each case, followed by a cross-case analysis. The researcher developed an elaborate narrative of the findings based on the primary and secondary data sources to address the research questions and produce a scholarly report of the findings and analysis. This was followed by the development of recommendations and implications for future research (Yin, 2015). The validity of the findings was further strengthened by discussing them in light of the literature and the context in which the study was conducted. To strengthen the findings further, the researcher reviewed the report again for a critical explanation of the findings and to identify any discrepant cases.

3.10 Concluding remarks on the chapter

The multiple case study and different sources of data collection were guided by Merriam (2009), Lodico et al. (2010), and Baxtor and Jack (2008). The data collection methods, which included semi-structured interviews, observations, field notes and reflective journals, were selected to establish and enhance the research's credibility, validity and reliability. The data analysis was based on guidance from Braun and Clarke (2006) and general qualitative rules posited by Yin (2015). The three case studies, consisting of 15 teachers, six parents and 11 students aged between 8 and 11, represented a purposive sample. The classroom observations involved the researcher visiting schools, recording various interactions and activities and taking field notes and audio recordings, followed by semi-structured interviews. The detailed data descriptions and transcriptions were compiled, organised, stored and assessed through coding and thematic analysis. Peer debriefing and member checking were used to ensure the trustworthiness, accuracy and credibility of the data and results.

The next chapter presents the data which was collected and interpreted through this process in order to address the research questions. The research findings from the participants in all three schools are described in detail, with a separate section for each case study, then cross-case analysis is provided.

4 Chapter 4: Findings

4.1 Chapter overview

This chapter sets out the findings obtained from the classroom observations and interviews with teachers and parents in the three case study schools (hereafter, S1, S2 and S3). The data collection was guided by three research questions (RQs), as follows:

1. *To what extent are parents and teachers aware of the concept of executive function difficulties in Saudi schools?*
2. *How is technology being used to support students with EFD in Saudi schools?*
3. *What are the main contributions that parents and teachers see technology making to the learning of students with EFD?*

The data collected regarding RQ1 revealed similar views among teachers and parents across all three schools, with a lack of awareness and knowledge and similar challenges in using technology emerging as common themes. As a result, findings related to the first research question are presented thematically rather than by school. However, data gathered in respect of RQs 2 and 3 are presented within the context of each case study, along with a description of the site and the participants' characteristics.

As quickly became apparent, the study participants were not aware of the concept of EFD and perceived these difficulties as characteristics of other diagnostic groups, such as autism, ADHD and dyslexia. Therefore, the term "EFD-like difficulties" is used here when describing participants' responses and points of view.

4.2 Lack of EFD awareness in participants

This section presents findings on the general awareness and knowledge of teachers and parents from all three schools regarding EFD. A lack of familiarity with the term "EF" was evident; however, participants were able to see how the term might be applied based on their experience with students with learning difficulties (LD). The following sections set out their understanding of the distinguishing features of EFD and the perceived characteristics of students with EFD.

4.2.1 Lack of familiarity with the term "EFD"

Participants' responses when asked how much they knew about the concept of executive function indicated that the term "EF" was not used in the Saudi educational context; teachers had never heard it in professional discussions nor raised it with parents as a concern. However, once the concept was explained by the researcher, they reported identifying such difficulties in students, "but never [having] labelled them as executive function issues". Although they identified a range of behaviours which are consistent with EFD, they tended to describe them in more general terms. The following quote typifies their views:

> *"I have experienced teaching students with similar difficulties, like autistic students being inattentive, forgetful and showing behavioural issues. However, this term is new to me. Generally, a more popular term in KSA is students with special needs" (T1; S1).*

Parents' responses also reveal a lack of familiarity with the term. However, they reported that their children exhibited patterns of disorganised behaviour and are "forgetful and lack focus" due "to the learning difficulties they possess", and that this could be connected with EFD. As one parent put it:

“Based on your explanation, my son might have that kind of thing. He is just different and has a different way of learning and exploring things but in a disorganised way. He is smart but it is difficult for him to get and stay organised and get things done in a proper sequence” (P1; S1).

These comments imply that while parents were unaware of EFD as a term and a concept, they considered the characteristics exhibited by their children as similar to EFD, once it was explained by the researcher. Their responses also indicate that the major challenges observed in their child were lack of focus, memory issues, and becoming easily distracted.

The responses indicate that this study brought the term EF to the teachers’ and parents’ attention for the first time. This suggests that there is a lack of information about EFD and little guidance for teachers to help them to address EF issues.

4.2.2 Identification of EFD in diagnostic groups (autism, dyslexia and ADHD)

Participants from all three schools perceived that neurodevelopmental, cognitive, and behavioural disorders (for example autism, dyslexia and ADHD) create EF-like difficulties, including lack of attention, focus, memory and organisational skills. They also recognised that there were variations in the severity or extent of their learning and behavioural challenges among students in these groups. The participants reported that there was no standard assessment format to identify them as students with EFD, but their LD and further behavioural challenges characterised them as such. Teachers also mentioned students’ requiring constant explicit instructions and feedback, clear control, direction and guidance, and a structured and organised classroom environment to keep their learning behaviour directed. As one teacher explained:

"From my experience, I believe these students have a problem with attention and remembering things, they have a problem with impulse control and are not organised. Their lack of attention limits them from following instructions. They are dependent on an external help/assistance to keep them in direction. I have observed that autistic and ADHD students are the most potentially challenging group for these difficulties" (T1; S2).

During classroom observation in S3, the researcher noted that students (mainly with those autism and ADHD) were moving around randomly and wasting instructional time. It was difficult to orient them towards a task. They were only seen to engage if teachers provided them with some reinforcement or reward, such as promising them the iPad to play a game, or their favourite sweets.

Most of the teachers reported that the major area of concern in these students is "keeping their attention, behaviour and focus regulated" through constant guidance and monitoring. Two of the teachers mentioned that they have to make extra effort to keep the lessons interesting and engaging for these students to be able to complete a task and reach some meaningful end. This includes providing structure, such as organising and planning the whole task, as students miss out important dates, timely reminders, and notifications of their activities.

Parents also perceived LD or challenges as arising from their neurodevelopmental disorders, and meaning their children had to expend extra time and effort to learn and adopt a new skill. They also identified a lack of persistence with tasks in their children, and complained that keeping their attention on a task was a challenge:

"My son is autistic, and he has memory issues and difficult behaviour. He is not easy to control. It is always a struggle to get him to do homework and make him sit in one place, he is easily unfocused and withdraws from any task unless I help him. He gets distracted once he hears any sound or sees anyone come into the room. Overall, he takes a lot of time to understand my requests" (P1; S1).

Although the teachers and parents had no formal knowledge of EF, the main challenges they identify in these students are indicative of EFD: firstly, these students need additional effort with planning and organising tasks due to a lack of focus and attention; secondly, their behaviour is not constant, and needs to be directed through proper planning and helping with their difficulties in WM; thirdly, they need clear directions and constant prompts.

4.2.3 Perceived characteristics of students with EFD

The findings from all three cases illustrate that participants perceived that attention and lack of focus is a core distinguishing feature of the students that may have EFD. This is identified as a factor contributing to these students' lack of ability to memorise items. Furthermore, they believe that their shifting from one task to another is due to a lack of impulse control to complete the given task. Thus, constant external prompts and assistance are required to keep students from moving on to unrelated activities. The extent to which the student is disorganised or lacks self-regulation and task persistence, or the ability to recognise the information needed to achieve a goal, is also identified. However, they believe that the reason these students behave this way is that they are disorganised, and cannot plan and manage aspects of their classroom activities or home-based tasks. Additionally, according to the teachers, these issues are reflected in students' inattentiveness towards instructions. As one teacher reflected:

"I see many autistic students and ADHD showing withdrawal from the task, hyperactivity, and inattention during the lesson. They also exhibit impulsive behaviour, that is, fidgeting, restlessness, being unable to sit still. I have to work a lot with them using different techniques to keep them directed. This includes various verbal and physical prompts, and sometimes cues. I have observed they will perform better when I set a visual reminder on their device when I assign them multiple tasks" (T2; S1).

The parent participants also attributed these challenges to a lack of focus, and inattentiveness. Among multiple difficulties, parents reported struggling to get their children to pay attention to a task, screen out interferences and distractions, and control habitual responses:

"I would identify the EFD of my child chiefly through the inability to focus on what he is learning. Most of the instructional time is wasted on disciplinary action for him. His ability to remember instructions is low, and this results in poor task performance" (P1; S1)

These reported behaviours indicate that important cognitive processes needed for progression in different academic skills are not developing properly in these students, and that targeted interventions, approaches and learning strategies are required. These will require both teachers and parents to know more about the EF challenges students with autism, ADHD, and dyslexia face, so they can be appropriately supported in both home and school settings.

The second theme to emerge in all three schools related to the challenges and constraints limiting teachers in their effective use of technology. These are reported below.

4.3 Technological challenges in teaching and learning for students with EFD

Multiple challenges and barriers were identified as limiting the effective use of technology to address the learning and EFD-like difficulties of students. These are significant as they identify areas for improvement in order to realise technology's full potential in addressing EFD-like difficulties.

4.3.1 Lack of training and development facilities

The findings indicate a lack of professional training and monitoring from authorities in respect of updating teachers' competencies and skills so they determine the most appropriate pedagogy, strategies and tools to help students with different levels of difficulties. For example, they mention that they need training which is directed towards enabling them to apply learning strategies for effective use of technologies and instruction to help students overcome stress, getting unstuck (flexible thinking) and independent learning. This reflects the lack of effort by authorities to maintain effective training and development for teachers to support successful technological integration and use. Observations showed that teachers were not very knowledgeable about the professional and educational use of technology to address LD, and the respondents identified lack of training as the cause:

> *"We have to make a lot of effort to understand and use a technology. There are smart ways for our technology to facilitate learning at a greater pace but that needs training and workshops. Unfortunately, that is missing" (T1; S1).*

The teachers reported that the authorities occasionally assess technology availability in each classroom; however, there is no monitoring of how teachers use those technologies to promote better learning in students with EFD. Many teachers reported that they opted for self-training due to this gap.

They also identified the need for education on better use of technology for students with EFD:

> *"Every student has different learning needs, and they require different solutions. For that, we need to be trained enough to customise the features of a programme and install more up-to-date software to address their lack of competence" (T3; S1).*

> *"The Ministry of Education needs to provide more training courses on how to use technology with these students. We also need to be kept updated and professionally up to date on any new programmes, tackling technical problems with devices" (T3; S2).*

> *"I'm always helping myself with online tutorials and reading articles about what could be effective. I'm not very familiar with the details for using the right application for my students" (T2; S3).*

> *"I learn many things on my own when I feel I am missing something new in my field. There is a lack of knowledge and content-based provisions, and courses and training and should be considered on a significant basis by supervisors" (T1; S3).*

These responses suggest that technology has been implemented without adequate training, and, as a result, interventions are not as effective for students due to technology-based instruction not being executed effectively.

4.3.2 Administrative support to advance technological integration

Among the major concerns communicated by teachers in all three cases was lack of administrative and technical support. This is aggravated by the perceptions of what high-tech devices can offer students who have attention and focus issues. The complexity of these devices may also become a barrier for these students and affect their pace of learning. T1 comments:

"Devices can fail. The complex features of some programmes and devices, due to technical issues, may interrupt the learning pace of students with attention and focus difficulties. The mechanical features of these devices are another challenge, and we don't have enough technical support".

Teachers also recognised that students have different level of difficulties and needs, so addressing their individual needs requires customised programmes and individualised plans that in turn require optimum technological devices to be available. A teacher stressed this point:

"I hope the school administration will facilitate and update the technological devices, as each student has a different level of difficulties. Technology is replacing paper, so there should be more investment in replacing old interventions with updated devices" (T2; S2).

During classroom observations, the researcher noted that, while the teacher was busy with another student, one student rushed over with his iPad and fell, smashing the device. T4 identified the risk factors when leaving a student who can have disruptive and impulsive behaviour alone with a device and the need for constant monitoring, and it was proposed that an additional assistant in the classroom would help address this problem:

"These students cannot be left alone with devices for long periods. They are unpredictable and throw devices at times. The probability of damage and breakage is high. So, an assistant teacher in the classroom would help monitor such activities" (T4; S1).

"One-to-one instructions are important in making gains with technology, so that an assistant teacher in the classroom will help address questions and provide guidance to students at the same time" (T1; S3).

This demonstrates that supporting students with EFD effectively via technology can be a challenge for teachers without adequate technical and administrative support.

Having identified the common themes, the following sections report the findings obtained from each case study.

4.4 Case study - School 1

4.4.1 Description of the site

S1 is in an urban area in Riyadh. Most of the people in the surrounding area are white-collar workers (in companies in the private sector). Many are not originally from KSA, but all of them are from Arab regions and speak Arabic as a first language. S1 is committed to providing special education services and facilities to children with specific LD, including autism, dyslexia and ADHD. Under the supervision of the MoE, the school provides educational facilities and support services to students with special needs at three levels: kindergarten, elementary and intermediate. The classrooms were equipped with educational facilities, and each class had smartboards, projectors, and computers installed.

The following section presents the demographic characteristics of the participant teacher group in detail.

4.4.2 Characteristics of participating teachers

A sample size of five full-time male teachers was recruited from S1. These teachers were from the special education department and had significant experience with SEN students. Table 4-1 presents the demographic data collected from these teachers, including their age, years of experience teaching students with LD, and experience using technology.

Table 4-1: Demographic characteristics of the participant teachers (S1)

Code	Gender	Age	Teaching Experience	Tenure in Current School	Experience with LD / SEN	Experience Using Technology
T1	Male	45	12 years: Masters	12 years	12 years or more	5 years
T2	Male	40	11 years since 2009: Bachelors	4 years	9 years	4 years
T3	Male	26	4 years: Bachelors	4 years	Dyslexia specialist: 4 years	4 years
T4	Male	35	8 years: Bachelors	8 years	8 years	5 years
T5	Male	39	10 years: Masters	8 years	10 years	10 years

4.4.3 Characteristics of participating students and parents

The participant students were selected with the consent of both their teachers and their parents. Three students (two with autism, one of whom also had ADHD, one with dyslexia) were selected from the same class. The fathers of the children with autism (only) and dyslexia were interview participants, and their detail are provided below. Parent 1 (P1) had two children, enrolled in sixth and fourth grade respectively. P1 reported that his 9-year-old autistic son exhibited characteristics that entailed LD, hyperactivity and lack of attention, as well as challenging behaviour. He further reported weak memory and difficulties his son faced in learning tasks, as well as a lack of IC and continual switching from task to task.

The second participant (P2) was a 40-year-old male with four children: three boys and one girl. P2 reported his struggle with his eldest son who was diagnosed as autistic prior to enrolling for school. The noticeable characteristics he observed in his child included a lack of focus on tasks when alone, being rather active, but being shy to take the initiative. P2 identified that his child struggled significantly to complete tasks and exhibited restlessness, switching from one step to another without completing the task. He identified that his child needed external help constantly to complete his work, as he was easily distracted by any sound in his surroundings. An overview of each participant parent's characteristics is given in Table 4-2.

Table 4-2: Characteristics of participating parents (S1)

Code	Gender	Education of Parent	Employment of Parent	Children With LD	Experience With the Use of Technology
P1	Male	Masters	Professional	1 autistic child	Yes
P2	Male	Masters	Working/Govt employee	1 dyslexic child	Yes

The following section presents the findings obtained with regard to RQ2: 'How is technology being used to support students with EFD in Saudi schools?'

4.4.4 Participants' views of the use of technology in schools

This section reports teachers' and parents' attitudes and comments in relation to the use of technology-based support for students with EF difficulties. In particular it considers their preferences regarding both traditional and technological approaches, the affordances offered by technology, and the different strategies they used in the classroom to overcome the academic challenges these students face.

4.4.4.1 Integrating both technology and traditional approaches

The classroom observation recorded balanced use of traditional teaching methods and technological tools, and most participants commented that students with EFD-like difficulties learn and respond best to lessons that integrate both traditional instruction and technology. Via this approach, the interviewees believe, the engagement and focus of students with EFD can be maintained. While teachers reported a preference for using technology for interactive learning sessions for students, they felt that technology alone cannot be the only solution to address EFD-like difficulties, and that a balanced mix of teacher-led instructions and technology was more beneficial. This preference for technology changes with circumstances, as T3 reported:

> *"I prefer technological tools more at times and traditional techniques when needed".*

Similarly, T1 stated:

> *"I believe in supporting the right proportion of both traditional instructions and technology. Dependence on technology is not preferable, as it has repercussions".*

Observations indicated that technology was accommodated, as with any other tool, but that it was often used just to keep students attentive in regular lessons. It was also observed that teachers lacked the necessary professional and technical skills to fully exploit the available technology. Whatever purpose technology was used for, teachers did not allow students to over-rely on it, nor did they consider it an acceptable substitute for traditional methods:

> "*Technology has great potential to keep attention, and [for] interaction with teachers and other instructions. I am not averse to using technological devices in teaching, but I use them as additional support in my teaching process; like, to keep them attentive, I play a video as a break when they get bored".* (T4)

The findings obtained from parents indicated that they were aware of potential technology-based benefits for their children, and they appeared to be more oriented towards a blended teaching design. P1 stated:

"It is a technological era; a lot of technological devices are being used in learning now. I am not sure about their full effectiveness, but what I have learnt is they retain and motivate my son's attention in learning. He likes lesson games that he plays on the iPad".

The selection of technology also emerged as an important theme in S1 and findings in relation to this are presented below.

4.4.4.2 Selection of technological devices

The findings reveal that the selection of technology varied according to the situation and the availability and the facilities provided by school authorities. Typically, projectors and smartboards were used for joint interactive activities and display of lessons taught; whereas iPads were used to play games and watch videos as a reward after an instructional session. During the classroom observation, it was noticed that smartboards, computers and iPads were frequently in use. The condition of all devices was good to medium, with some new versions of all devices available. The smartboards were installed as an interface similar to a traditional blackboard, and personal computers were available for each student. The devices were appropriately placed to make them easy for students to access; for example, smartboards were placed at the front and personal computers aligned appropriately in the classroom.

In technology-dependent educational settings, teachers were observed to prefer devices that are easy to carry, for them and for the students, and which require less cognitive and physical effort for students. However, multiple technology integrations are a challenge to maintain, requiring more time and effort in maintaining and upgrading systems, and multiple technicians and specialists. T5 commented*:*

"Having so many devices will require different specialists, and I am not that sure the school has many specialists to fix different devices if they go out of operation".

This lack of professional expertise to manage more technology resulted in a less favourable attitude towards using and integrating technology from teachers. T4 commented:

"Presently, we predominantly use three different types of technology. It is quite time-consuming and takes more energy for students too. I hope that each class can be equipped with one type of device that is easy to use and carry, and one that the teacher has been well trained to use".

During classroom observation of group learning, teaching was carried out in groups (five groups). Each group used a single computer, but it was difficult for the teacher to retain the attention of everyone together. However, when using the smartboard, one student came forward, as selected by the teacher, making this more convenient than the computer. Concerning iPads, this device was observed to offer ease of use and engaged students the most individually.

The selection of technology also raised parental concerns. Parents were of the view that the choice and use of technologies should not be as a distraction or a break from study, but for facilitating learning. One parent reported:

"*I am aware of my child's use of technology in the classroom. I believe iPads and smartboards are a convenient device for them, but if it is supporting their learning rather than distracting their attention from the educational content".*

4.4.5 Ways to ameliorate EFD using technology

As understanding suitable ways of using technological tools to address EFD is a crucial objective of the research, teachers and parents were asked how they thought EF skills could be improved by using technologies such as iPads and tablets. They focused in particular on the appealing nature of the technology, its impact on engagement, and the ways in which different EF skills could be enhanced, and their responses are presented below.

4.4.5.1 Appealing tasks to retain the attention of students with EFD

Teachers reported that students with autism or ADHD can struggle to engage in complex cognitive processes, with weaker engagement in a learning session and an inability to retain focus leading to forgetfulness. To help engagement, child-friendly games and videos are played to focus their attention. For example, different games and applications were installed on an iPad/tablet, and once students were given an iPad, they were 'zoned in' through frequent instructions and assistance from the teacher. During the observation sessions, it was noted that students with autism were not attentive when teachers were instructing them regarding a task, and they appeared to be daydreaming and totally unconcerned about what the teachers were telling them. However, when teachers switched to iPad-based activity, those students were alert immediately without any prompting. The teachers mentioned that this is a good way to develop their attention stamina. For example, T1 commented:

> "*Getting their attention is not a simple task. I prefer to use tablets more than a computer when dealing with individuals, as they have fewer attentional demands. Also, with iPads, attention is retained and is not reoriented. Students enjoy the learning as the iPad interface makes it engaging".*

These findings indicate that technology is used as a motivational tool to make learning an enjoyable experience. Moreover, it appears that technology-led learning can attract and retain attention and that step-by-step instructions can help to enable flexible thinking and appropriate task shifting.

Parents believe that technology-mediated lessons help students develop attention control, as they follow the instructions given by teachers more closely. This suggests that parents consider them effective for controlling students' behaviour, as they keenly follow multiple-step directions. P2 identified improvements in task focus and IC in his son when using iPads:

> "*Using iPads, he focuses and completes the task as well as follows up a step. The devices prevent withdrawal from tasks.*"

Improvement in attention span was also reported by parents as a potential gain made through these devices, and they believe this will assist with other difficulties. For example, P1 commented:

> "*iPad programmes have won my son's attention. He rarely paid attention to vocal instructions previously. But the iPad engages him a lot; he wants to know and learn things and then stays on it for some time. So, yeah, I think the iPad helps my son to focus on something.*"

4.4.5.2 Behavioural, emotional and cognitive engagement of students with EFD

The teachers' responses indicate that using digital screens, such as iPads, smartboards and even computers, engages students, retains their interest in lessons, and helps avert disruptive behaviour exhibited through affective reactions. T2 stated:

> "*I have seen students motivated to rush to the screen when a lesson (stories) or video is to be started. I usually encourage them to finish their task off-screen to start the learning session on the iPad.*"

The observations indicated that the integration of technology in various aspects of learning distributes the extraneous cognitive load to the digital interface, meaning both teachers and students are flexible and engaged to learn. For example, in an interactive iPad activity, different pictures and audio were used for students with autism to communicate and improve their cognition, wherein they were able to hear their pronunciation. They were also enthusiastic to repeat the names of the images shown on the iPad. T2 commented:

> *“The repeating word game on iPad makes them happy, I see a satisfied expression on their faces, especially when they hear their own voice. This motivates their learning behaviour and improves cognition. I have found this programme quite helpful when I am using it with my students”.*

The teachers also demonstrated positive attitudes towards the iPad and the easy-to-use features that enable them to help children to learn through repetitive practice. T3 noted:

> *"It is rare for these students to remain engaged or listen in any session, but, if I incorporate iPad or smartboards, they become alert by virtue of the visual and audio features. Their attention span is enhanced".*

This suggests that technology with customised features can be used to engage students who are behaviourally, emotionally, and cognitively challenging and that creating a favourable context for using devices, such as child-friendly applications and language, appropriate length of task, and interactive design and delivery methods with intermittent assistance from the teacher, can help to address students’ LD.

4.4.5.3 Enhancing core EF skills through multi-component technological features

In addition to improvements in cognition and attention, the teachers demonstrated that self-regulation could also be directed with the use of devices at appropriate intervals. For example, students were keen to learn through iPads, so, while teachers had to give occasional prompts in a traditional reading session to keep them focused on the book, when he played an audio video book on the iPad, the students were seen to be engaged, and they sat in their seats for long periods. This was an evident improvement in impulsive behaviour, and it also reduced teacher-directed hints and prompts as they watched the video without getting distracted.

Another teacher repeatedly asked questions interspersed with the names of fruits, colours and shapes by repeating a video, at which the student chuckled and pointed and responded effectively. The student was also observed to swipe across the video being played to watch the part in which he was most interested without external assistance. This activity therefore facilitated different EF skills, including WM (remembering the colour, number and names of fruits), and CF (by switching between different shapes, colours and fruit names). In addition, once the student learned to move between the different features of the application, he gained independence and asked for fewer directions. This suggests that such activities can help students feel more positive about their ability to explore and learn things themselves.

In addition to these functions, it was observed that some students with autism were somewhat challenging for teachers as they would leave their assigned seat and repeatedly fidget. This loss of focus and being easily distracted during lessons to a lack of IC. Teachers were seen using different strategies involving technology to address this. Firstly, they would direct the student's attention and focus by giving them playtime on a tablet, and then incorporate a video-modelling strategy by playing a video of the desired classroom behaviour on the tablet. They also instructed students verbally, reminding them that this is work time and it should be silent time. They then allowed them to play with the relevant application, such as a puzzle game involving matching words and letters, or a tracing puzzle to practise writing. The student would wear headphones attached to their device to avoid distractions in the classroom.

The application sound and feedback kept them engaged and moving to the next level.

Observations also showed that, in sessions involving technological aspects, there were students who required constant monitoring and assistance to use devices. Here teachers modelled through physical and verbal support. For example, the hand-over-hand method, in which the teacher placed his hands on the child's hand to guide his movements through an activity, was used to enable child cognition, increase the attention paid to the content on screen, and to help the student point to the particular subject. This reduced both technical demands and any difficulties operating the device, which potentially improves learning. T4 commented:

> "*I believe that, to overcome the complex cognitive and spatial demands of these students, using iPads and smartboards is more convenient and increases attention to the content being learnt because, with handheld screens, the cognitive demands are reduced, and it even enables me.*"

Teachers also noted that verbal support is necessary when students engage in technology-mediated learning, including repetition and clarification about the content being displayed or the activity being learnt, reading the text on the screen aloud, commenting or acknowledging something on the screen, and providing step-by-step instructions as required. They reported that this directed students' attention, helping them shifting from one task to another more easily, and enabling cognitive flexibility in the students. For instance, T5 reported:

> "*When using technology, we have to be involved with the student to avoid multiple task overload, which may further impact their memory, to remember instructions and to use the device. So, to overcome this I keep providing them with hints and repeated instructions by asking*

them direct and indirect questions, for example, "Where is number one on the screen? Can you tell which is a triangle among all these shapes?". I also provide them with hints for an activity (for example, "So that means…?", ''a triangle has how many corners?" "Tri means….?")".

However, some teachers had concerns that students with ADHD and autism are vulnerable to screen time effects, as their obsessive tendencies and over-focus when engaged with technology may add to their sensory and behavioural issues. Moreover, students with EFD, having low IC, may get distracted through irrelevant content and tabs. The tendency to become distracted by other things, such as other apps on the device, calls for guided use, and close monitoring and evaluation by both parents and teachers. Both T3 and T4 commented on this in particular:

"Yes, it sometimes disrupts their learning. Students switch from one application to another application that doesn't relate to the lesson. I have to check their use frequently and reduce screen clutter". (T3)

"Yes, students might become over-focused with devices at times. This is something to be kept in consideration. And removing the devices can make them lose interest in the learning". (T4)

These findings indicate that the use of devices is controlled and maintained through frequent verbal and physical support and supervision from teachers. This also reflects the teacher's intention to keep the use of these devices controlled and to track the student's performance while using technology.

4.4.6 *Technology overcoming academic challenges for students with EFD*

Teachers were also asked about the use of technology to address academic challenges in particular. They highlighted its role as an auxiliary aid and the way it enables multiple sensory approaches to learning for these students.

4.4.6.1 Using technology in combination with traditional methods

Another view expressed by the teachers was that EFs impact students' academic level, and that technology serves as an auxiliary aid and facilitative support to help them overcome academic issues. Technologies are modified or customised in such a way that they facilitate, maintain or improve the functional capabilities of the student with EFD and used in conjunction with other teaching instructions and interventions to address task persistence, improve attentiveness and increase adaptability and memory capacity.

For example, in the classroom observations, students with EFD exhibited difficulties managing time and getting started, and haphazard ways of performing tasks, indicating their lack of organisational ability. Teachers had to prompt them regularly in order for them to remain engaged with their task. Examples of these prompts included tapping them on the head, and sometimes their peers would tap the desk to make them refocus. They also had problems managing basic facilities to perform tasks, such as organising papers and the equipment necessary for task completion. Their poor attention was also exhibited through their unresponsiveness to the teacher's prompts. At this point, the teacher would set timers and reminders on their tablets or iPads to keep them working. Knowing they had a device with an alarm reminder on it motivated students to initiate and resume work when distracted. Thus, as T2 explained:

> "*Technologies are supporting materials or tools but require a teacher's assistance. Academic challenges cannot be overcome by using only technologies without traditional methods. Technologies can be used for supporting traditional methods.".*

Significant improvements resulting from using technology-based learning in this way were reported by teachers, including improvements in cognitive and social functioning. Moreover, using smartboards individually and in groups resulted in better reading and language comprehension skills among students. T1 shared his view that:

> *"Students' memory and attention is significantly improved with the use of computer/iPad-based programmes. Thus, I believe this is further contributing to their reading skills, as different games and applications help them memorise the name or sound of the letter; [and improve their] ability to pronounce new or unknown words through tests and retests and constant practice."*

These responses indicate that difficulties similar to EFD exhibited by students can be addressed through a combination of traditional and technological approaches, and that academic abilities are also improved. However, the support offered by technological tools, such as iPads/tablets, is particularly helpful in facilitating the repetition and practice these students need.

4.4.6.2 Facilitation through multiple sensory approaches

The observations and interviews also indicated that the multiple sensory aspects of technology can improve student's capacities in comprehension, critical thinking, and reading by engaging different senses. For example, using iPads and smartboards enabled them to use multiple sensory approaches and perform media multi-tasking, in listening, touching, and observing the screen, all at the same time, as well as rehearsing activities on-screen. T4 noted:

> *"Multi-tasking on-screen helps students to navigate between different functions. It can enable them to easily differentiate between word similarities, different word sounds and vocals. This helps them to read and improves their language competencies".*

T5 added to this view by discussing how his students with dyslexia have tried to learn difficult words using different speaking applications. He noted:

> "*I believe that the best teaching approach to help overcome academic challenges is technologies as they allow multiple sensory integrations. iPads and mobile applications were quite helpful for my students in learning difficult words, like long words or words that have the same spelling with different meanings."*

4.4.7 Strategies to facilitate technology-mediated learning for students with EFD

Teachers were also asked about the particular strategies they used to facilitate technology-mediated learning for students with EFD-like difficulties, and teacher-student interactions, the use of scaffolding, and the effectiveness of prompting questions emerged as key themes.

4.4.7.1 Teacher-student interactions to address students' EFD

Teachers reported using both regular instructions and technology to enable conceptual connections between different aspects of the task, and the observation sessions showed them employing both verbal and non-verbal communication skills effectively with students who had multiple difficulties.

The findings indicated that teachers prefer giving support at regular intervals to engage the student, and that they adjust their support and interaction based on each student's need to develop independent learning (that is, they provide contingent assistance). T1 stated:

> *I decide the tools and level of assistance according to the level of their difficulties. Most of the time, through modelling and direct instructions, [this] addresses their problem and then gives them ample time to practice. In this way, they feel independent to practice skills".*

4.4.7.2 Scaffolding for technologically mediated learning

Classroom observations showed that, during teacher-student interaction, scaffolding was widely practised to help students with a specific task or activity. However, it was also evident that most of the assistance for students with EFD was given by their classmates, except in particularly difficult cases, while teachers moved from one group to another.

T1 commented on the use of scaffolding and its impact:

> *"I have experienced that supporting students repeatedly and then reducing the assistance, but monitoring their performance and observing them remotely, promotes independent learning in them. Their performance improves gradually, and they are free to operate the particular programme themselves".*

Another teacher added T4:

> *"A new programme on the device requires additional support at the start. I help them with demonstration and clarification, with questioning and answering. To assess their learning and memory, I ask them the questions and then gradually fade my support to see how long they will remember. This imparts in them independence, limits them in moving from task to task aimlessly, and improves their persistence".*

When using technology, teachers used scaffolding to support the learning process by providing instructions on how to use the relevant methods and requests. For example, during the first stage of an activity during a classroom observation, the teacher helped a student press a picture of a mammal to produce the sound of its name, and then match it with the appropriate word on the smartboard. This entailed direct instructions and interactive teacher behaviour. It was also observed that an exchange of questions and answers took place that related to enhancing attention, as well as WM, because the student was memorising how to reach a specific page on the device.

4.4.7.3 Using questions to assess improvement and learning

The interviews and observations indicate that the use of question prompts was a prominent approach in fostering effective ways of learning and tracing progress after the gradual fading of support and assistance. For example, during an activity requiring students to indicate different shapes on-screen, the teacher first identified a triangle, and a short time later, gave a prompt:

> "*This is the triangle in red".*
>
> [After practising for some time, the teacher then prompted the student]
>
> *"Can you show me where a triangle is on the screen?"*

Observation indicated that students were more likely to focus when supported in this way because the question prompt helped them focus on effective ways to memorise.

In addition, Teacher 3 commented on the value of the smartboard when using questions to measure students' understanding once activities had been:

> *"It is my practice that, at the end of the lesson, I develop a set of evaluation questions to measure the students' understanding (including students with autism spectrum disorders), by using the smart board digitally and traditionally"*.

These findings indicate that teachers' scaffolding when using technology reinforces the connection between learning content and learning behaviour. Figure 2-1 below illustrates how teacher-student interaction (scaffolding) mediated by technology to ameliorate EFD-like difficulties.

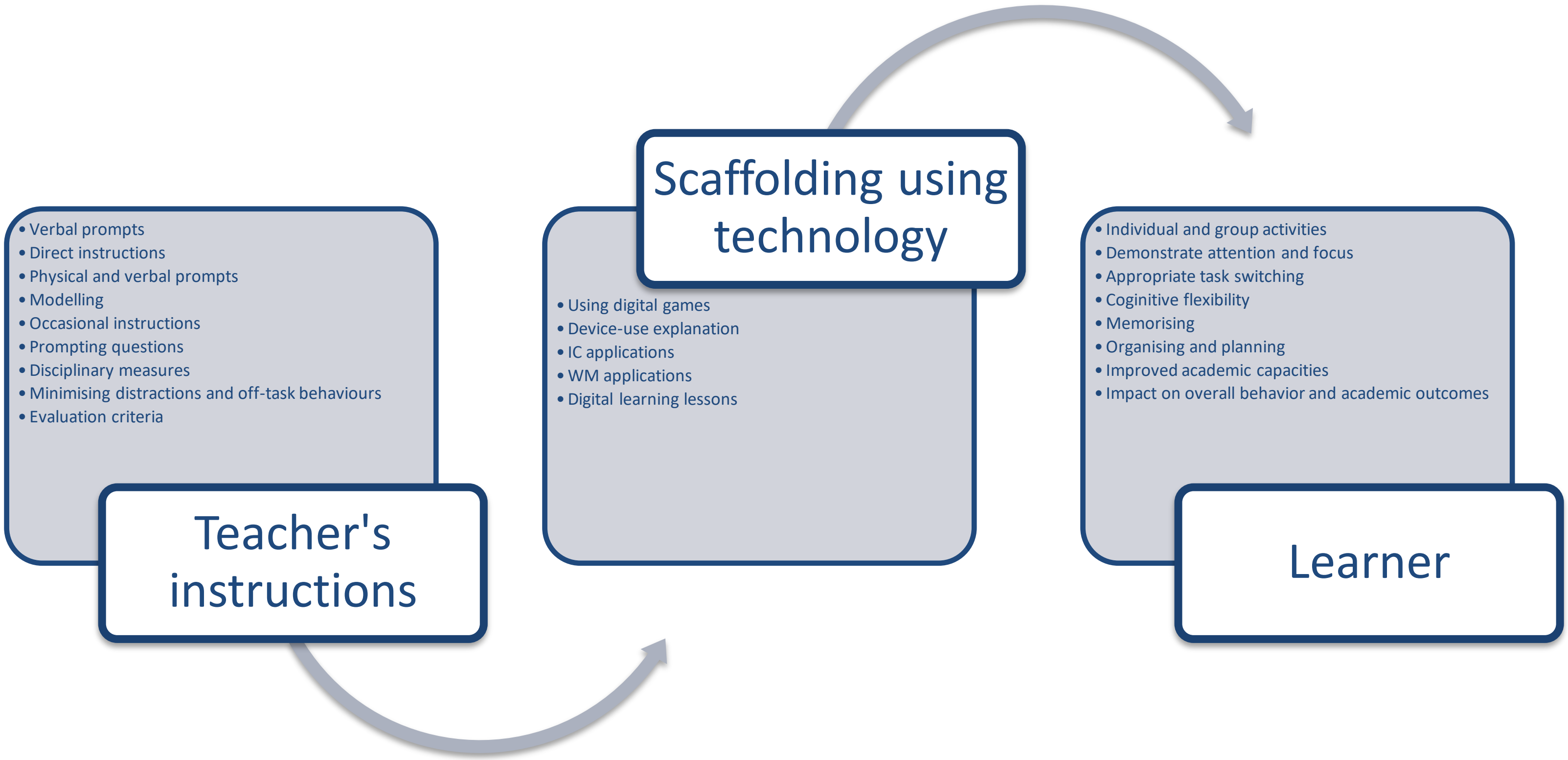

Figure 4-1: Teacher-student interaction mediated by scaffolding that uses technology to improve EF skills

The next section presents the findings obtained in respect of RQ 3: 'What are the main contributions that parents and teachers see technology making to the learning of students with EFD?'

4.4.8 Affordances technology offers for students with EFD

Both teachers and parents provided useful insights into technology's contribution to enhance both students' general learning and their academic achievement, as EF skills and general learning are linked. The observations were also particularly instructive in this regard, particularly in providing examples of technology's mediating role.

4.4.8.1 Technology's supportive and mediating role

The interviews and observations reveal that technology was used for all students with learning and behavioural difficulties to regulate their behaviour and enable them to overcome anxiety and aggression, thereby enabling them to perform better in the classroom. T1 commented:

> *"I have observed a better learning pattern and academic performance after being instructed through devices. I use iPads sometimes to overcome the aggression and boredom they show during regular classroom sessions. That helps me keep their interest".*

During classroom observations, the researcher saw that a student with ADHD was having handwriting issues and the teacher was helping him to hold his pencil and write more effectively. However, he was becoming agitated and losing interest in practising. Then, the teacher introduced the tablet and opened the writing practice application for him, which involves tracing letters and words. The instant feedback the application provided when letters were traced without distortion represented an instant reward for the student, motivating him to practice again. It was also observed that some students were typing notes, and the teacher helped them take pictures of important learning points on the white board, so they could revise them later at home. This was, therefore, a good assistive feature to help them.

Another teacher was observed adding a task to a student's 'to-do' list on an iPad's task manager application. The application allowed him to set a deadline for each task, add subtasks to each major task, and assign dates using the built-in calendar feature. This was to ensure that students (and parents) could check the upcoming assignments and projects that students should complete. This feature also notified the student about missed tasks by highlighting them as overdue. These findings suggest that these assistive features and functions of technology help teachers aimed to enable students with EFD to self-regulate and organise their activities; this is achieved by developing their prioritisation skills and helping them in memorising their important tasks.

In this context, parents also mentioned the rewarding role of iPads in motivating their children to practice important but challenging tasks. They also expressed that the rewarding nature of the apps also inhibited their impulsive behaviour. P1 mentioned:

> *"I practice reading a digital book along with him as he is dyslexic. And sometimes, we practice phonics using the game where he enjoys the creative screen and tools of the game. He does not even get embarrassed if he makes a mistake, as the application tells him to try again, and he is happy to do so".*

This indicates that the creative features and the interactive screen encourage students with EFD to learn. However, many responses indicated that technology was also used as a mediator to control frustration, and as an entertainment tool to provide a break from other learning activities. Teachers' attributed this to the capacity of technology to offer students an avenue to alleviate boredom and aggression. T4's comment reflects this perspective:

> *"I have experienced a significant improvement in frustration and behavioural tantrums of students with the use of technology as a leisure activity in ADHD and autistic students when they are not listening to my instructions. I give them a five to ten minute break, and they can enjoy the device time, and then we continue with the lesson again".*

These findings suggest that these teachers use technology as a motivator to engage with traditional, teacher-given instruction or to give students a break. This may indicate that these teachers prioritise teacher-oriented instructions, rather than using technology as a learning tool in its own right.

Parents also reflected on the contribution of technology to the overall learning of their child and to enhancing their creativity. They believed that technologically mediated learning seemed to have a long-term academic influence*.* P1 expressed his views on this:

> *"Initially, with traditional methods, I have never noticed my child performing so well and creatively. But, after using technology I have observed his frustration has reduced; the device has made him a better learner, happy, relaxed and a [more] disciplined student too".*

4.4.8.2 The need for teacher mediation for students with EFD

The teachers emphasised the significance of their mediating role in enabling students with multiple difficulties to benefit educationally from the use of technological devices. Most of them pointed to the importance of observing and analysing each student's learning process while engaging in learning tasks through technology, reflecting their belief that technology cannot replace the teacher or other learning materials. For example, T2 explained:

> *"I would not say that technology is a 'potential fix' to learning difficulties and the other challenges for these students. It requires the role of the teacher equally; their monitoring and supervision are very important for these students to keep them on the learning track in collaboration with other learning materials; otherwise, they are daydreaming when not attentive".*

The classroom observations also indicate that the role of the teacher in using technology contributes significantly to the benefits students derive from it. While students were not focused when teachers were just giving explicit instructions, combining technology's motivational factors with their instruction and support was shown to direct attention and promote engagement. For instance, one teacher said to a student with ADHD *"sit straight, listen to me, eyes on me, concentrate." The s*tudent looked at teacher, but then turned his head towards other chairs and students, looking unconcerned. The teacher then turned on an iPad and helped the student trace letters on an application by putting his hand on the student's hand. This guided and mediated learning directed the student's attention and controlled him.

Overall, it was clear that these students, when given an experience with technology, would pay active attention. Moreover, the immediate feedback from the apps showed they were actually engaged and not just looking at the screen. The sound of applause was reciprocated with a smile on their face. These findings indicate that the teachers' presence is essential in attention stamina development, as well as in establishing that actual engagement and learning are taking place.

Parents also expressed this view, noting that their students must possess the attention attributes if they can use devices for a long time, but that mediation of both teachers and parents is key to realising the full potential of technology to support them. For example, P1 commented that:

> *"I believe my child possesses the attribute of good attention. How is he sitting for so long on a device if he has attention issues? It is just that we have to keep guiding them through interesting learning features that will enable their learning, like when they learn to play a game because it is of their interest".*

4.4.8.3 The importance of traditional classroom material to address EFD

The interview responses also indicate that teachers perceive the role of other physical classroom materials and resources as being equally important in addressing learning challenges and EFD-like difficulties faced by students. As one of the teachers mentioned *"Technology is but among one of many other educational tools for these students"* (T3), and another teacher stated:

> *"I would not totally rely on technology, but yes, I may use it as a free time tool after books and other options. Low technology tools serve their purpose too, so I believe in using both and I would not replace old things that work with these students."*

The teachers' responses indicate that they perceive technology's potential for improving the learning experience of the students when mediated by them and by blending it with other classroom resources.

4.4.9 Key Findings

In summary, the following key themes were extracted from the data gathered in Case Study 1:

- Participants prefer to use technology for some tasks, but their teaching strategies involve using both technology and traditional methods;
- Teachers employ a variety of instructional strategies and technology to engage students with EFD, including attention, independence and self-regulation improvement through physical and verbal support, and multi-component technological features;
- Technology offers facilitative support in improving response to academic challenges through multi-sensory approaches;
- Teacher-student interaction is found to be effective when coupled with scaffolding as an approach to using technology and in addressing EFD-like difficulties in students.

The next part of the chapter presents the findings from School 2 (S2).

4.5 Case study - School 2

4.5.1 Description of the site

S2 is a primary school situated in the centre of Riyadh. The population in this part of Riyadh mainly comprises Saudi nationals, including white-collar employees, such as government employees and armed forces personnel. A total of 22 classes are divided across three levels: kindergarten, primary and elementary. The classrooms are equipped with technological tools for students, such as interactive whiteboards, iPads and a PC for instructors. The student population is 390 children, aged 3 to 12, and includes students with learning challenges, such as autism, dyslexia and ADHD; however, there was no evidence of cooperative teaching between the general and special education departments. The national curriculum is used in the school, with pedagogical components incorporated into individualised educational plan. These plans contain elements based on the student's current level of study difficulty. The faculty staff were well educated, with significant experience teaching students with LD.

4.5.2 Characteristics of participating teachers

A total of five teachers participated in data collection from S2, all of whom were male. These were qualified teachers with a specialist background in teaching students with SEN and LD. Table 4-3 below gives detailed demographic information regarding this participant group (gender, age, years of teaching experience, educational level, experience with LD (learning difficulty) students and proficiency in using technology), as these factors are influential in determining overall student-teacher interaction, and students' development and achievements.

Table 4-3: Demographic characteristics of the participant teachers (S2)

Code	**Gender**	**Age**	**Teaching Experience/ Education**	**Tenure in School**	**Experience with LD And SEN**	**Experience Using Technology**
T1	Male	34	8 years approx. Masters degree	Since 2016 (5 years)	8 years; direct teacher to LD students	5 years
T2	Male	29	9 years Masters degree	Since 2016 (5 years)	Since beginning of career	Last 5 years, since its adoption
T3	Male	39	15 years Masters degree	Since 2011 10 years	15 years/LD teacher from the start of career	Since 2016
T4	Male	30	5 years Bachelors degree	Five years/2018	Specialist teacher for LD students for last 5 years	1 year
T5	Male	32	7 years Masters degree	Seven years/2015	Seven years	Since 2016

4.5.3 Characteristics of participating parents and students

Two students with autism, two with ADHD, and one with dyslexia were selected for observation for Case 2. These students were aged between 8 and 10, and exhibited varying degrees of specific learning and behavioural difficulties. Information about each student participant was collected during the interviews with the parents and teachers and is provided below.

Two parents from S2 volunteered for the present study. Parent 1 (P1) was 48 years old and a father of five. P1 represented his youngest son, an eight-year-old student with autism enrolled in Grade 4. The second participant, Parent 2 (P2) was a 44-year-old father of four. Two of his children, aged 9 and 7, were enrolled in S2, with the younger child having dyslexia. An overview of each participant parent's characteristics is given in Table 4-4:

Table 4-4: Characteristics of participating parents (S2)

Code	Gender	Education of Parent	Employment of Parent	Children with LD	Experience With the Use of Technology
P1	Male	Masters	Working/Govt Employee	1 autistic child	Yes
P2	Male	Bachelors	Working/Govt employee	1 dyslexic child	Yes

P1 reported his son as being an autistic student with many challenges, some of which include a lack of focus and short attention duration, and losing interest rapidly. The inability to control his impulses leads him to switch from one task to another without completing the first. It is also a significant challenge for teachers and parents to get him to focus on tasks which are not appealing to him.

P2 reported his concerns regarding the younger child, who has dyslexia and poor communication skills. He said that his son struggles with learning and often has trouble starting and finishing his work. Memorising is another challenge for him, and he also exhibits frustration that upsets him for long periods.

The two students with ADHD were aged 9 and 10. According to their teachers, they move around constantly and fiddle with objects, and are seen to talk excessively. They are inattentive and lack focus in long lessons, particularly in repetitive activities that lack creativity. These challenges limit their ability to perform academically. This is evident in their lower confidence levels, as exhibited by reduced participation with their peers.

Having described the study participants, the next section presents the findings which relate to RQ2: ’How is technology being used to support students with EFD in Saudi schools?’

4.5.4 Participants’ preferences and practices in respect of technology

This section presents the participants’ views on the use and adoption of technology-based support for students with EF difficulties, particularly the use of traditional and technological approaches together. It further discusses the different instructional strategies used by teachers to make effective use of technology and traditional methods to achieve academic progress in students with EFD-like difficulties.

4.5.4.1 Integrating technology and traditional approaches for students with EFD

Most teachers were oriented towards using a variety of content and incorporating multiple strategies into learning sessions to address both general and EFD-like difficulties. While they endorsed the use of technology to support students with different LD, they expressed the belief that relying on technology only would yield narrow transfer effects. They agreed that, although technology offers ease and convenience, and opportunities for repeated practice, it does not ensure that the student is also learning out of this technological context. T2 commented:

> *"Technology has many benefits, but our major focus is to make the learning context wider, with a mix of traditional and technological [approaches]. Using PECS/flashcards/notes may not solve all the problems. So, multiple features of technology along with a mix of traditional strategies, that is, audio-visual features, retain their attention".*

In addition, T5 stated:

> *"A combination of traditional teaching and digital tools, that's what I prefer, and I do this in my regular teaching. For me, there's nothing that can replace the gentle touch of humans. No matter how advanced the technology that we have in the classroom, the role, existence and significance of a human teacher could never be replaced".*

This indicates that teachers value the opportunities for practice which devices offer, that they see them as convenient, and as offering effective student interaction. It also signals recognition that it is difficult to engage students and enhance their learning through traditional lessons only. However, they also have doubts about relying on technology, especially as it is prone to errors and issues, and appear to be orientated towards teacher-centred instruction to keep a level of control that fits the students' understanding through modelling, verbal physical prompts, assistance and monitoring.

The findings from parents revealed a greater concern with their child's engagement and interest, and whether they would at least focus on the lesson, rather than whether a traditional intervention or a device was used. However, they did not deny the importance of a balanced approach which includes both. For instance, P1 commented:

> *"I prefer him to use an iPad or a PC for learning. Luckily, his schoolteacher often uses an iPad or Smartboard when teaching. It's good to keep my son quiet at least and attentive, I know that the traditional approach is also important, but for my son's case, at least for now he can follow the lessons. An iPad is a must, and I also bought him one".*

Thus, the findings suggest that, overall, both teachers and parents prefer a mix of traditional and technologically-mediated lessons to avoid any negative impacts of the use of technology alone.

4.5.4.2 Repeated practice with multiple types of content

Teachers and parents acknowledged the importance of repeated practice through devices to address different challenges and LD; as T5 mentioned: "*One-time practice would not produce a long-lasting transfer effect"*. They also consider technology as a valuable means through which to engage and retain the interest of students with multiple challenges. They also expressed the belief that the number of times a student is involved in these learning activities determines the effectiveness of any technology-based lesson, and that, if students are persistent in performing a certain task on a device, they will maintain their improvement. For instance, T1 commented:

> *"Practice and repetition are key to achieving maximum improvement. I believe devices offer a potential medium to drill and practice. Regular instruction and practice are quite taxing for them, and they may lose interest."*

These participants also placed particular significance on the transfer effect of the programme/intervention being used through the devices. They believe that repeated practice and regular reinforcement may produce maximum gains, but the transfer effect will determine the actual contribution. T2 commented:

> "*Repeating the steps and instructions of the programme on the device helps students retain the information. I look at their results to determine transfer effect".*

An example of this was seen during the observation sessions. The teachers first used flashcards of different shapes, colours and items, and used funny sentences to make students remember information about the object. However, after a certain amount of repetition, the students with EFD-like difficulties began fiddling with other objects. The teacher then started the session on the smartboard and opened a memory match game with similar categories of items to those shown on the cards (fruits, colours, shapes), and requiring students to memorise the names of the items. It was clear that this attracted the students attention and engaged them for a longer period, along with constant monitoring and instruction from the teacher.

4.5.4.3 Technology as a multi-dimensional aid for EFD

Teachers highlighted the versatility of digitally-mediated lessons and the ability of devices to aid in multiple instructional purposes. They consider that students are more motivated and learning is reinforced when they are directed towards devices, enhancing their attention, controlling frustration, and directing behaviour towards learning, rather than constantly switching to other activities. For example, T4 commented that:

> *"Devices allow me to control their active and passive learning, and regulate their behaviour. For example, the interactive whiteboard enables me with its different options for use. It is a means of visual reinforcement, and, at times, I allow active participation and interaction between themselves and with me on an electronic programme*".

These responses suggest that technology serves as a facilitative tool by offering several options to direct the attention and energy of these students towards learning, which may otherwise be lost in a prolonged instructional session.

Teachers also reported that technology can be used as positive reinforcement to achieve the desired behaviour, including greater attention and focus. However, the role of the teacher is key. As T1 elaborated:

> *"Technology, for me, is a facilitative tool, a reinforcer to get their attention and direct them towards learning. I prefer devices that are controlled by me, that is the projector, where I show them video stories and then collaborate with them to gauge their progress. Handing the technology over to them is not the solution to their complicated problems that need proper guidance from the teacher".*

This demonstrates a cautious approach towards adopting technology, and reflects the view that too much dependence on technology is not an effective approach.

4.5.4.4 Selection and availability of technology

The observation sessions recorded three main types of device in classrooms, all in good to medium condition: smartboards, iPads/tablets, and personal computers. The smartboards were installed next to the regular chalkboard, while iPads were distributed to each student (some of the students had their own iPads). Teachers also had personal computers/laptops.

Observations indicated that that technological choices were based on learning style (whether more oriented toward visual or audio/verbal instructions) and students' affinity with particular features of the technology. Most teachers were in favour of using the smartboard and iPads to better facilitate group learning. T4 stated:

> *"iPads and interactive smartboards are used the most. When I have to give one-to-one instruction in a group, I use a smartboard the most: that helps me monitor the student progress in a group session more effectively."*

However, T3 held a different opinion regarding the selection of devices, saying that he uses devices as a last resort for students:

> *"I have a different approach towards using technology: I prefer projectors, where control is more in my hands to keep their attention, and I use it as a last option if other things fail to produce the desired results."*

This implies that the teacher's choice of technology is aimed at accomplishing group results, and that they are more oriented towards using a collective mode of technology.

The provision and availability of devices also determine the teachers' selection. As T2 reported:

> *"In the classroom, we have been provided with smartboards, personal computers and projectors. The iPads are used the most because all the students have them at home too".*

Thus, teachers are dependent on authorities for access to technological tools, so whatever is available is used and customised according to learning needs.

4.5.5 Different instructional strategies and technological tools for EFD

Both teachers and parents acknowledged that technology-based approaches can be productive where the appropriate strategies are implemented.

Therefore, this section identifies the strategies adopted by teachers for the effective use of technology and instructional approaches.

4.5.5.1 Multiple context-specific strategies to address EFD

The teachers agreed that the correct mix of instructional strategies is fundamental when using technology to address multiple difficulties. Since the study participants are from different diagnostic groups (with autism, ADHD or dyslexia), different, context-specific strategies may be required for each student. T4 commented on this as follows:

> *"My context-specific approach is to do task analysis first, that is, identifying needs and intended outcomes, reinforcement and prompts required at that moment, monitoring the student's use of the application, and then fading my support and prompting to check their independence and maturity of skill."*

Observations showed that students with similar needs (students with ADHD exhibiting lack of focus, attention, and memorising difficulties) were guided one-to-one by a teacher, who provided constant verbal reinforcem*ent: "Excellent! You have started the programme yourself",* followed by, *"Now show me your 'to do tasks' page. Whoah! You have done it, bravo! Now let's start today's lesson".* This suggests that the teacher's instruction and strategy, along with appraisal and reinforcement, had engaged the student's attention, and that using the device had already prompted him to focus on the screen.

Among the various strategies used, the teachers also used a group-based learning approach. For example, during observations, the researcher noted that observed participants exhibited impatience and were restless at times, hoping to gain the teacher's attention to ask for assistance. This was due in part to the large number of students in the class, which also made it difficult for the teacher to monitor every student. To address this, teachers arrange group-based interactive sessions. T4 commented on the importance of this:

> *"As we know, we have less external assistance to help each student here. What I do is incorporate group-based joint learning and pair these students with difficulties with the peers who are better at learning, who then instruct and guide them when learning through the device. This has also helped to prevent students getting involved in off-task behaviour, and they are kept managed by their peers".*

This indicates that the teaching and learning process in a setting where there are students with different EFD and with differentiated instructions can be difficult to manage effectively, meaning students lose interest and focus on learning. It also suggests that teachers lack adequate skills and support to address the multiple needs and challenges of students through technology. They are more adept at attending to students in a group or pairing them with more academically able classmates to provide the extra support they need.

4.5.5.2 Modelling and demonstration

The findings indicate that the teachers' support for each sequential learning phase actively engaged the students. The technology-based learning sessions were constantly guided by teachers either through instructions, modelling, or using certain types of support, to facilitate the lesson and address students' needs. T1 explained their approach as follows:

> *"For effective use of device-based lessons, we firstly perform and model the task, and then let students use the device. I use the right visuals to support my lesson, meanwhile monitoring their interaction with the device and the progress they make for more difficult steps".*

It was observed that, during one of the phonics activities arranged for a student with dyslexia, an application with rhyming sounds was used by the teacher. The student was attentively engaged with both the device and teacher (having eye-to-eye contact with the teacher when he modelled the word, and then engaging with the sound and visual stimuli on the iPad). When the student faced difficulties in pronouncing a word, the teacher again modelled and repeated it on the iPad, and then asked the student to repeat it, until the point where the student had mastered the phonic and could take more responsibility for reading by himself.

T4 also acknowledged the student-teacher interaction as an effective means of controlling and managing student frustration, stating:

> *"It is important to guide them through intermittent interaction. I make interesting gestures that are definitely supportive for them. Then I talk to them a lot. This, you know, modelling and gestures helps them imitate me. So, what I do is model the task first, question them on their understanding, giving them hints when required, and provide feedback on positive responses. Then I also add visuals from the devices. This as a whole makes a real learning combination".*

Student-teacher interaction was also seen to be effective in providing students with appropriate direction until they were able to independently complete the task. This indicates that the use of teacher-student interaction, with contingent support and coupled with technology, can be an effective approach to help overcome the challenges faced by students when performing a task.

However, despite the supportive views of this teacher, it was observed that personalised exchanges required greater one-to-one attention from teachers, and that, although the time when the teacher addressed and instructed each student was an interactive learning phase, some students' attention deviated from the lesson afterwards, perhaps because they were still not ready to use the program independently.

In addition, it was observed that a single teacher providing instructions and observing the entire class at once was not able to address the questions and problems of each student fully in a way that would allow them to develop the skills required to perform the task. The teacher introduced the application, demonstrated the task procedure and familiarised the students with the programme. This worked for a few students, enabling their independence, self-monitoring and regulation; however, others started looking to the teacher again, raising questions about their ability to use the device.

4.5.5.3 Targeting specific EF functions

The findings show that teachers and parents understand the value of technology in enhancing attention, engagement and academic performance in students with multiple challenges. The teachers reported that lack of attention is a major obstacle for students with autism and ADHD; however, their experience indicated that technology is an effective medium to obtain the attention of these students and that it motivates them to attend school, improving the time spent on learning and instructions, and significantly contributing to their scores and grades. As T2 commented:

> *"When educational applications and tools are used effectively, it significantly increases student attendance rates, and their overall academic progress is improved".*

In addition, the lack of attention was attributed to boredom and suddenly zoning out from a learning session due to inattention and inability to focus, as they developed interest elsewhere. For example, an student with ADHD was observed as being somewhat disengaged while his teacher was instructing the class. The teacher asked him to read from the whiteboard, but he ignored the instruction. One teacher mentioned that they must *"figure out their elements of interest and top joys that will avoid their boredom and stimulate them towards learning rather than being disruptive"* (T2), and technology's features were seen to address this need for stimulation, and to hold these students' interest. For instance, another student with ADHD was observed being disruptive while the teacher was instructing the class about performing a numerical task. The teacher used effective step-by-step approaches, with technology used as a reinforcing and supplementing tool to address behaviour. Firstly, he seated the student away from doors, then he opened an application that had addition and subtraction games. He gave the student individualised instructions to practise the task on the application and repeated them intermittently. Afterwards, he gave the student a golden star sticker on his hand as a reward for maintaining that learning behaviour.

This suggests that, along with facilitating other classroom accommodations, strategies and instructions along with technology, students with EFD can be directed towards focused learning and improved behaviours.

4.5.5.4 Improving core academic skills

Both teachers and parents reported that the use of multiple interactive components of technology along with student-specific instructional arrangements is effective in improving different academic skills, such as reading, writing and numeracy. For example, P1 spoke about the impact of the iPad on his son's numeracy skills:

> *"Different applications on the iPad, like subtraction and addition games, have helped him improve his numeracy skills that he was not able to do with the regular method. He loves to count on smartboard and iPad and touch the symbols/objects. He is happy to do regular practice on his favourite iPad".*

One observation lesson included the use of an application with a picture-matching and sentence-making activity to develop vocabulary skills, early numeracy skills (addition/subtraction), and literacy skills. It was observed that students were excited to use this. They followed the teacher's instructions and game features, and were successful in making sentences, doing calculations and in the reading activity. This indicates that the engaging combination of text, audio and video options offered by the devices increased the students' interest level and encouraged them to engage. T2 commented on this, saying:

> *"The power of devices to engage them has enabled me to practice application-based reading and writing with them. The word prediction feature has overcome their frustration and the anxiety of overthinking with regular writing and reading. They have developed more interest in this practice and their reading and writing scores have improved as well".*

This suggests that the visual elements of digital learning tools were effective in maintaining students' concentration on the task, and aided teachers in communicating their instructions, resulting in improved overall learning and academic skills. Classroom observations also supported this idea. For instance, a student with dyslexia and hyperactivity was observed becoming distracted during manual book reading with his teacher, and struggling to read and comprehend the text. Due to that he was losing motivation to read the long text. To stimulate his interest and focus, the teacher opened an iPad-based reading application and began modelling the application features of reading and spelling for him. The student became engaged and enjoyed himself while learning via the application. The large font on the application also allowed him to understand and concentrate on the screen with interest.

This also illustrates that students' confidence and eagerness to use the iPad for reading and other learning activities was significant, particularly in overcoming the resistance shown in regular reading activities with their peers, where they often pushed back due to embarrassment. P1 reported evident improvements in motivation in his son as follows:

> *"I never expected good results from my child, but yes, I have seen him trying to read and write on an iPad screen using the assistive tool, so it satisfies me that at least he is learning. I cannot put him in the category of regular students here."*

However, teachers felt that the reliance on technology to seek academic improvement is not always appropriate, and it is not proven to be positive in all cases. T3 expressed this perspective:

> *"We know that these students are more interested in digital lessons and have access to digital devices all the time, but this does not prove that we need to move them away from standard instruction. To achieve further gains from devices and to have optimal academic performance, I believe the primary source for improving skills in these students should be general instruction".*

This indicates that while teachers acknowledge the benefits of technology, they understand that LD vary in degree and level in different diagnostic groups, and the overuse of technology to teach a lesson just because it engages these students is not a sound reason for this strategy

The following section presents the findings from S2 addressing RQ3: 'What are the main contributions that parents and teachers see technology making to the learning of students with EFD?'

4.5.6 Technological affordances are useful for learning for students with EFD

This section reflects on teachers' and parents' perceptions of the potential affordances of technology for students with EFD-like difficulties. It addresses current contributions of technology to general learning, and explores existing and potential challenges that may affect the role and affordance of technology in managing these difficulties.

4.5.6.1 Technology-enhanced learning improves planning, organisation and self-regulation

The findings indicate that technology-based learning sessions actively engage these students and thereby improves their learning capacity, for example, by reducing their distraction level and frequent switching from task to task, which often impedes their learning in a conventional classroom setting. T1 referred to this, saying:

> *"Normally, it is quite a challenge to keep their motivation, engagement and concentration over time in a learning activity. But, with a device, their motivation is directed towards learning, unlike in a conventional learning setting."*

In addition to this, teachers mentioned that these students have obvious self-regulatory and organisational challenges, such as trouble focusing on and following a task or instructions, "careless" mistakes due to inattentiveness, losing important items, and problems with other activities that require focus and concentration. They mention that this further adds to the students inability to manage, organise and keep track of the time required for each activity. To address these issues, they used several manual and digital assistants to support the students in class. For example, several visual aids were displayed on students' desks and on the walls of the classroom, with schedules and calendars to notify them of important dates and times for activities of the day to be followed in their daily routines.

However, for more sensitive and complicated students who needed personalised attention, devices were used to keep attention on the task, understanding of coming tasks and assignments, and to develop the ability to stay organised. Teachers mentioned using tools such as digital organisers, reminders and schedules to enable students to arrange and organise their work properly, to reduce confusion, and to help them remember deadlines for their projects and assignments. T4 reported:

> *"They have issues with remembering deadlines and keeping up with classroom schedules. The digital tools are easy and effective in enabling them to remember important tasks. So, I set a reminder on their devices for important homework and task completion".*

An application on iPads that features a visual schedule planner was reported to be relatively effective by teachers. They believed that it could be used by parents at home as well. The teachers expressed their belief that this application was serving three purposes to address students' EFD by organising and self-regulating them. Firstly, thought that it was improving student engagement through simple features in the form of audio, video and pictures that maintain attention. Secondly, that it was providing pedagogical assistance by presenting sequences of tasks that draw students' attention and helped with self-organisation by keeping track of events and the assignments they have to do each day. Thirdly, the app. has can be customised according to the learning level of each student, such that they would not become frustrated while setting it up. T2 spoke about his experiences using this application:

> *"I found this visual schedule application on the iPad quite helpful for autistic, ADHD and other students having these difficulties. It is interesting for them, as I add pictures too with daily schedules. It*

empowers them with independence to keep track of their daily schedules. It engages them and helps them understand the importance of the time each activity requires. They also learn about the transition of moving from one activity to another. This further improves their ability to transition from one activity to another".

Parents also mentioned how they would sometimes develop a morning and bedtime routine using this application. They believed it to be an effective function of the device, which helps their child both at school and home, as it develops their motivation towards daily scheduling and remedies their disorganised attitude towards various matters. P2 reported:

"I have seen my child quite motivated to check his iPad from time to time to see what he has to do next. He sees the different daily activities like morning routine and bedtime, and then he also checks through the schedule his teacher has set up for what he has to bring school and what he has to pack for the next day".

These findings indicate that such features serve as an aid to help improve self-efficiency for students who face memory challenges and issues in planning, organising and managing time to complete an activity. These organising, planning and self-regulating features of the technology help to address students' forgetfulness and memory issues by enabling them to stay on track and remember important details. This in turn directs them towards developing self-regulation, organisation and self-management skills, which are typically among the greatest challenged for students with EFD.

4.5.6.2 Technological tools improve academic performance in EFD

Most of the teachers reported that technology is indispensable in their academic settings, due to its ability to create a real-world environment for discovery and examination for students with persistence and memory issues. Different technological tools for reading, note taking and organisation (e.g. graphic organisers) help support students with structure and organisation, making them better able to develop academic skills, such as reading and writing. T3 commented:

> "*Different features of a technology programme like MS Word help them create a checklist that improves their task initiation, time and material management, and also eases their difficulty in remembering things. Similarly, for organising their tasks, we use digital file organisers and electronic organisers".*

Teachers also mentioned that students who exhibit difficulties, such as being disorganised (being late to class and showing a lack of readiness) and losing classroom supplies (notebooks, pen, pencil, notes) can be directed to self-monitor and self-regulate using digital checklists to strengthen their actions and memory. T2 explained:

> *"It is fascinating to create a checklist with the touch of a button. The device's interface makes an overwhelming task much more appealing. For example, ADHD students, are often not prepared for class and are always missing important things due to their forgetfulness. I help them through visual support and using features like checklists on their devices. You know Google Calendar is an easy software available on iPads and other devices, so I help them create a digital schedule and calendar for their assignments to be completed, and other important upcoming tasks, and I synchronise their device with mine and*

sometimes their parents for reminders to remain updated about important upcoming events and tasks".

This supports the idea that technology tends to help students having difficulty remembering and structuring their thinking, through its multiple features. It also indicates that teachers are generally positive about the affordances of technology in enhancing students' self-management and organisation, by making them more aware of tasks and events, and helping them to develop more organised pieces of work.

4.5.7 Key Findings

In summary, the following key themes were identified from the data gathered in Case Study 2:

- Participants believed that technology is effective when integrated with a mix of instruction, strategies, and content for students with EFD.
- One-to-one instruction and scaffolding have the most potential as instructional strategies for effective and appropriate use of technology along with traditional teaching for students with EFD.
- Technology-mediated learning significantly improves multiple academic skills and addresses challenges in students with EFD.

The next section presents findings from School 3 (S3).

4.6 Case study - School 3

4.6.1 Description of the site

School 3 (S3) is a mainstream primary institute located in Riyadh. The surrounding area is largely populated by Saudi families, mostly white-collar workers who are employed in the state sector and ministries. S3 is situated next to a secondary school and shares a building with that school. S3 provides a special education curriculum to students with learning and developmental difficulties (mainly autism, ADHD and dyslexia). This curriculum is different from the general curriculum provided for mainstream students. The teaching staff comprises experienced teachers with a specialisation in education.

S3 has a total of 370 registered students, including both mainstream and special education students. Students with mild to moderate learning and developmental difficulties attend primary classes from ages 8 to 11. The observation sessions recorded that classrooms were equipped with basic learning tools, such as chart papers, printable visual supports, calendars, schedules, pictures and flashcards. In addition to these traditional tools, classrooms were equipped with high-technology devices. The four main devices at the time of observation were smartboards, iPads (some provided by authorities and some brought by students), personal computers, and digital projectors.

4.6.2 Characteristics of participating teachers

Five experienced male teachers from S3 participated in the study. These teachers said they could use the available technological devices within their respective classrooms, including smartboards, iPads, personal computers, and projectors, but they also mentioned that they had to work this out for themselves. They had not been provided with any additional or special training to use technology, and they had never been invited to collaborate to develop resources and techniques. However, they knew enough to use them with students, often by cooperating and discussing issues with each other or gaining assistance online. Table 4-5 presents the demographic details for the teachers, including gender, age, years of teaching experience, educational level, experience with LD students, and proficiency in using technology.

Table 4-5: Demographic characteristics of the participant teachers (S3)

Title	Gender	Age	Teaching experience/ Education	Tenure in school	Experience with special students	Experience using Technology
T1	Male	37	10 years Masters degree	10 years	10 years	Since 2016
T2	Male	47	13 years Masters	7 years	Specialist in LD/Since the beginning of career	Last five years, since its adoption. Had previously been using traditional methods
T3	Male	39	8 years Masters	3 years	LD teacher for eight years (since joining the profession)	Since 2016
T4	Male	36	5 years Masters	5 years	Specialist LD teacher since 2016	Since 2018
T5	Male	31	Four years/Bachelor	2 years (since 2019)	Four years	Since 2010

4.6.3 Characteristics of participating parents and students

A total of four students aged between 8 and 11 were observed: one student had a diagnosis of autism, one of ADHD, and two of dyslexia. These participants, with their different neurodevelopmental profiles, presented an interesting opportunity to observe variations in their developmental and behavioural profiles. The information collected about each participant during the interviews and observations is presented below. Two of their parents volunteered to be interviewed. Their details are summarised in Table 4-6.

Table 4-6 : Demographics of participant parents (S3)

Code	Gender/ age	Education	Employment type	LD of child	Experience with tech
P1	Male/43	Bachelors	Govt Employee	ADHD	Yes (iPad)
P2	Male/40	Bachelors	Govt Employee	Autistic	Yes (iPad)

Parent 1 (P1) represented his youngest son, a student with ADHD. According to P1, his son exhibits learning and behavioural difficulties, and an inability to remain calm due to his hyperactivity. This makes teaching him at home a challenge. The inability of the parents to sustain his focus on a learning activity made it difficult for them to keep him engaged during lesson instructions. He loses interest and becomes bored and is easily distracted by sounds in his surroundings. Once distracted, he cannot control himself to stay in one place during learning sessions.

The second participant, Parent 2 (P2), explained his youngest son's challenges as a student with autism. He exhibits problems in holding on to information. For instance, when asked to go to his bedroom and put his bag there, he always forgets what he went there to do. P2 also mentioned his son's stubborn behaviour and that he would not shift from one task to another easily. His lack of attention and weak memory affects his academic performance, notably his reading, spelling and comprehension.

The two remaining students, aged 8 and 10 respectively, both have dyslexia. The observation sessions showed that these students were messy, and the teacher had to make considerable effort for them to remain seated during lessons. One of them had lost his notes and books in his bag. He also exhibited frustration and distraction when he tried to read and was reported to skip parts of texts. He sometimes misbehaves, shows a lack of interest, and refuses to read.

The other student was observed constantly interrupting other students during the session, and the teacher made him sit on his own at the back of the class as a reinforcement. They both seemed to listen to the instructions from the teacher, but when questions were asked, they did not remember anything.

Having introduced the study participants, the next section presents the findings which relate to RQ2: 'How is technology being used to support students with EFD in Saudi schools?'

4.6.4 Preferences for the use of technology or traditional methods to support students with EFD

This section reports the choices and preferences of participants in respect of the use of technological or traditional techniques to address EFD-like difficulties in students. There was a wide-spread acknowledgement that no single approach could address the complex mix of difficulties associated with EFD; therefore, a combination of instructions and technological tools was a suitable accommodation for these students in most contexts.

4.6.4.1 Adopting a student-centred approach

The teachers considered that the correct mix of technology, curriculum, and instruction can help EFD students accomplish their learning goals. However, they expressed the view that combining technology with regular instructional approaches should be done by adopting a student-centred approach, where students' learning, cognition, behaviour, and – above all - their independence is regulated. However, it was observed that the use of both technology and general instructions was also an effective way to increase student independence in activities. Teachers also acknowledged that their students liked using technology. For example, T2 said:

> *"They can't be forced to learn through instructions only. An appropriate match between general instructions and technology-mediated instructions is important. If I keep exerting my efforts to win their interest and engagement, I won't be able to do that unless I use something to their interest and liking."*

Although teachers valued the affordances technological devices offer students with EFD-like difficulties, they also felt the need to keep up with modern trends. As T4 explained,

> *"Times have changed, as classroom learning can't depend only on chalk and talk methods. It is necessary to keep up with modern techniques, like incorporating the right digital tools as [using] a supplementary demonstration on-screen for these difficult students to focus [on] is effective."*

4.6.4.2 Technology is supplementary, and not a holistic solution for EFD

The participants' were clear that technology should only play a supplementary role. They did not report that technological devices achieved improvements in EFD beyond those of traditional teaching techniques, and they noted that there are many things to be considered when using technologies with other instructional methods, including cultural norms. For instance, T2 commented:

> *"We can be designers of our instructions, according to the needs and capacities of these students. Technologies have their complexities; they are not designed according to each student's tendencies. Currently, we don't have enough programmes compatible with our culture and norms".*

Teachers also expressed some concerns about the misalignment of technology with pedagogical content were. For example, T3 stated:

> *"Technology can't be a sole solution: alignment between devices (applications), curriculum and instruction should be maintained".*

This reflects the perception of some teachers that instructions and traditional techniques can be more intensive ways of involving students, and ensuring they focus on tasks. However, observation of an HD flashcard activity suggests that this is not always be the case. The students were being instructed about the names, colours and shapes of objects shown on the cards. The teacher had to exert different levels of effort with each student, as some took a relatively long time simply to listen, while others took a short time to learn and respond. It was, therefore, challenging for the teacher to balance everyone's needs simultaneously. However, during technologically mediated instruction – playing a video of the names of the objects – all the students were attentive and engaged with the screen. They responded to the teacher's questions, which demonstrated their concentration, as well as the more balanced effort required from the teacher to cater for all of his learners.

4.6.4.3 Technology as facilitator, motivator, and reinforcer

Despite their reservations, the participants' inclination to use technological instruction has increased because of its facilitative role in engaging the students. However, the teachers retain the motivating effect by introducing the devices for a short time during one stage of an activity in a learning session. T1 expanded on this:

> *"When it is device day, the atmosphere in the classroom changes. They get settled easily when I turn on the projector, smartboard or uncover the iPad. So, once I have gained their attention, I display the video or*

images of content, use instructions in small steps and deliver the content to be learnt in the whole process."

This was seen in practice in the observations with an application-based mathematics practice activity designed to promote early mathematics learning, wherein different photo puzzles, object classification, and patterns were used for concentration, problem solving, and mental flexibility skills. The students involved stayed quite engaged, asked questions, and asked for help from the teacher, who supported and assisted them intermittently to monitor their progress.

Printed reminders, charts, and calendars were used in the classroom to help students organise and manage tasks. However, digital reminders, highlights, note-taking and sharing, and timers were also provided, and it was observed that the interactive format of the visual screens on devices made these easier to use. In addition, T5 reported that he used technological devices as an auxiliary tool in the sessions to help students with EFD keep up with their classmates:

> *"I usually connect my iPad or mobile phone to the projector and even the smartboard to display images, videos and lesson content for teaching. This improves their coordination with other students at the same time to perform the activity and remain at the same pace".*

4.6.4.4 Selection and use of technology

The devices used in S3 at the time included smartboards and projectors and speakers, with projectors used as data displays (with other devices connected to it to play the required content or video) and speakers as a teaching aid. The participants expressed the belief that every technology serves a different purpose: some have more potential to gain students' attention, while others serve as facilitators for the learning process, and some simply function as motivators for students to stay attentive during instructions. Thus, a teacher’s preference for a particular technology depends on its availability, relative use, compatibility, interactive ease, and value in supporting instructions. T2 remarked:

> *"For me, the best technology is one that delivers the educational purpose and keeps up learning too. We have to select them for learning, not just to engage students, because they are always excited to learn through screens.”*

The teachers require devices that are safe to use, engage students, motivate and facilitate learning, and keeps students’ attention for longer, and their choice of a particular technological tool is associated with the relative advantages it offers. For instance, T1 preferred using a smartboard:

> *“I would prefer a technological tool on the basis of two functions. Like, if you see a smartboard, it offers more instructional ease, and it allows participation from many students. It also contributes to the students' collective learning process by saving time and effort.”*

Meanwhile, T5 found using projectors and smartboards was more effective:

> *"For me, using projectors (linking them to my phone) and smartboards is more effective than iPads or other technologies, because they engage student's senses effectively at the same time (seeing, hearing and touching) and connect all students together. I appreciate the active participation of students all together where I will pair a more knowledgeable student with one having issues; that will motivate them more to learn."*

Most of these teachers experience with these devices dates from the time they started teaching students with LD and similar challenges. This gives them greater confidence in the selection of the most suitable device to meet their objectives and support students most effectively. This indicates that the individual participant's previous experience with devices has a significant role in determining the technology's effectiveness.

Parents' view of technology use was found to be guided by their children's interest and readiness to learn. P1 described how he views using devices as a blessing for his children's learning, despite having some concerns:

> *"I have bought him a personal iPad, and I'm happy with the use of the device as he is ready to use it for learning and is engaged when some programmes are being played on it. His teachers have updated me about different programmes that I have to help him in doing at home, and we follow that."*

4.6.4.5 Concerns about the use of devices

Notwithstanding the positive aspects, uncertainties about the role of technology were also expressed, especially concerns about the impact on students if devices malfunctioned. T2 described the problem:

> *"You know autistic and ADHD students are difficult to get to focus, and regulating their behaviour for a lesson is another story. And if a device malfunctions and disrupts the progress, it is such a mess again."*

Concern about technical challenges also relates to teachers' session preparation and the extent to which they could depend on the technology to function correctly. Sometimes the internet connection fails, delaying lessons, and some teachers complained of issues with connecting wires. T2 described the impact of this:

"Sometimes we come prepared to class for a technology-mediated session, and the internet connection may not work or wires are faulty. This may happen in the middle of a session, which adds to the frustration of students and it is a challenge to control them then."

The teachers also identified other issues they faced and anticipated when using devices in the classroom. The most prominent of these included access constraints, lack of training, and insufficient administrative and technical support. For instance, T4 commented that:

"I see many constraints too. Sometimes insufficient devices; that is addressed by bringing my own and students bringing their iPads. And sometimes it becomes difficult for me to monitor each student individually to track if they are doing the lesson or just scrolling across the screen."

T5 raised the issue of the dual use of devices and the difficulty of ensuring students used them primarily for learning while in the classroom:

"These students are hard to keep on track altogether, especially in communicating that a device is only to be used for instruction and learning first, and then entertainment. I feel we have a lack of administrative and technical support too. We need additional staff for assistance to keep students on track."

Overall, these findings reveal that both teachers and parents acknowledged the importance of balanced use of traditional instruction and technology. Both reported the contributing role of technology as a motivator, facilitator and collaborative tool in the learning process for students with EFD. They also understood the contribution different tools could make and selected them on that basis. However, the role of quality instruction and its appropriate alignment with the use of devices was also emphasised, possibly influenced by the teachers' doubts about the reliability of devices in their classroom situations and the lack of specialist training and support available.

4.6.5 Different instructional strategies and types of support

Different instructional strategies and accommodations practised by teachers to address EFD-like difficulties were identified in both inclusive and special classrooms. Choices were made in line with the students' various needs, and included, for instance, scaffolding learning activities through devices, practice and repetition through modelling, keeping students involved through questioning, and feedback. Teachers acknowledge that this was important, as some students struggled to engage with instruction. For example, T5 stated:

> *"I think my difficult students are not engaged and listening to my instructions. If prolonged, I'll see off-task behaviours and potential disruptions."*

Classroom observations showed that different learning materials (flashcards, notes, printouts and worksheets) were arranged on each student's desk, so the layout looked neat and organised for students. Some teachers were explicitly reinforcing students' needs to arrange their tables, checking to see if they had the required items by calling out the names of all the materials. Teachers also reduced distractions from sound, light and colour by altering the brightness and audio settings on the devices, keeping them low during learning activities to avoid overstimulation.

4.6.5.1 Repetitive practice through scaffolding and differentiated instructions to address EFD

The teachers favoured providing collective support to a whole class through repetitive practice of any activity, using different ways of learning for the lesson. The identification of each student's preferred learning style enabled teachers to reduce the off-task behaviours of students with EFD, thereby retaining and improving their motivation to learn. T1 commented:

> *"I just work on repeat and practice formula. I allow them adequate independent time for practice after the right amount of support. Later, I assess their learning by asking them questions – exploratory class talk in different ways – to test their memory. I use different tests for an activity to see if they have learnt it from different perspectives. This is also important to improve their learning flexibility".*

T2 explained that repeating an exercise under supervision, with guidance and support, helped with the transfer of knowledge learnt:

> *"If I have made them learn about names of fruits in a lesson and in the next exercise, I made them learn colours and names of things using fruit, I will first ask the name of that fruit; they will select the right option on screen or say its name. I make them repeat it as a rhyme as a whole class".*

This suggests that a class-wide approach was adopted more than individual instruction, possibly because it was difficult to address each student's challenges and learning needs individually. However, this technique enabled students to practice the desired skill under the teacher's guidance and support, allowing them to acquire the desired outcome.

4.6.5.2 Individualised instruction and support with technology for EFD

Although a class-based approach to instruction was common, teachers acknowledged that some students work at a different pace and need one-to-one support and guidance in order to progress. This idea was supported by classroom observation. For example, a student sitting in the second to last row in the group was seen to be frustrated and still trying to understand an addition exercise when the other students had already finished. The teacher had to reach out to him and support him, and he was monitored individually for the rest of the session. However, teachers felt that the need for one-to-one assistance *from the teacher* varied according to the challenges each student faced, and that, in some cases, support from more able peers could be effective. T3 reported:

> *"It is cumbersome and time-consuming to reach out to students one-to-one; that is why we pair them in the group. They learn through the more knowledgeable peer in the classroom while practising. But, still, some of them need my individualised attention, instruction and modelling."*

This also reflects the notion that the quality of support is more important than the type of support.

T2 explained that his teaching style is more based on modelling and guided instruction as the lack of classroom support limited his scope to provide one-to-one guidance:

> *"Some of my students need one-to-one assistance. Otherwise, they may become frustrated by repetitive failure. They may give up trying under such cognitive load. So, I have to be available for them as much as possible, but this is difficult as there is no teaching assistant with me to monitor the other students completing tasks on devices."*

These findings illustrate that teachers prefer to conduct teaching and learning in a group and through one-to-one learning using a mix of instruction and device-based learning, with intermittent support (that is short, independent working sessions and practice by students).

4.6.6 Contribution of technology in addressing different EFDs

Overall, the teachers felt that the use of different technological features and applications have contributed to the management and reduction of EFD-like difficulties. Technology serves as reinforcement in this process by engaging students with attention, focus, and memory issues. The following findings were produced in this context.

4.6.6.1 Facilitating WM, time management, organisation and IC in students with EFD

The participants reported that students' evident interest in and engagement with electronic devices enabled them to facilitate learning and that specific functions were effective in addressing students' time management, self-regulation, and organisational challenges. For instance, T1 described how teachers set reminders, alarms, notifications, and used graphic organiser features on the student's iPad, in order that that assigned tasks, homework, and tests are duly prepared and not missed. He further explained:

> *"This is an amazing feature for sure. Their attraction to the iPad helps us with setting reminders, calendars and colour coding important dates of quizzes so that they don't miss out on an important task - a to-do list when they are at home."*

The multi-functional (and multi-sensory) aspect of these features was also employed by teachers. For example, it was observed that, when a teacher opened a student's planner on his tablet and added the memo for homework, he also added an audio recording to dictate the steps of the assignment to remind the student. On another occasion, it was observed he took photos of weekly lesson plans using the iPads and tablets to reduce the load of paper students had to manage, which would otherwise be difficult to organise.

Teacher 4 expressed similar views:

> *"The audio and visual notifications on important dates adjusted on the iPad are a blessing for me. Most of the students bring their iPads and it helps me a lot to set reminders accordingly. This feature also allows text reminders to be enhanced with different colours and emoticons that attract students' attention, and they check that notification".*

These simple device features help to maintain student schedules and diaries for items that students are otherwise unable to remember. This illustrates the point that teachers use basic technological tools that are easy for students to use and easy for them to maintain. However, it also reflects the need for greater teacher knowledge about more complex uses of additional applications and tools.

The following sections reflect on teachers' and parents' views on the most positive contributions of technology in addressing EFD in relation to RQ3: 'What are the main contributions that parents and teachers see technology making to the learning of students with EFD?'.

4.6.7 Technological affordances that benefit the learning of students with EFD

The teachers identified various affordances and potentials of technology in terms of improving student learning, motivating them to learn in multiple ways, and expanding their capacity to engage, memorise, and remain attentive. These teachers are also more likely to believe that technology is part of the future for improving the quality of education.

4.6.7.1 Improvement in academic readiness and learning skills

Retained interest, and enhanced engagement and focus emerged as major technological affordances for students with difficulties like EFD. Teachers noted that a direct technological interface offering a personalised approach for instruction improves engagement. They also thought that this facilitates organised use of concepts through integrated applications and appealing features that enhance students’ ability to handle information and remember tasks (WM). Moreover, they also stated that simple and easy-to-use controls on devices promote independence and self-regulation. T1 commented:

> *“The direct communication and quick visualisation in technology-mediated sessions improve their learning and memorising things. Their learning patterns improve, and they remember new concepts.”*

The findings indicate that the use of technology enables rehearsal of tasks to be done in an interesting way that also facilitates cognitive and behavioural function. For example, during a collaborative reading session on an iPad, in the feature 'speak screen', the teacher was observed writing a sentence for students and highlighting the text. This was then read aloud by an in-built feature, making it easier and more interesting for students to comprehend. The teacher then read it out for students, and prompted them to read one by one, praising them for correct responses by saying, "Excellent! We did it." Students were then seen to repeat the exercise.

4.6.7.2 Improvement in academic skills (reading, writing, comprehension, and mathematics)

In addition to technology’s potential to improve memory, engagement, and focus during instruction, many teachers were also motivated by its capability to improve academic skills, including reading, writing, comprehension and maths. T2 explained:

> “*The multiple practice option on the speech application, along with my direct instructions and guidance, is really effective. Likewise, if you see them practising a maths problem through audio and visual exercises on the iPad then on paper, [this] coaches their numerical skills.”*

Observations also indicated that technology-mediated learning can be an effective way to overcome distraction, as interactive presentations engage students with EFD and stop them disrupting the learning of other students. In addition, channelling their excess energy into digitally-mediated learning helps to regulate their CF and impulse control. For example, a student with ADHD was observed not paying attention to the teacher's instruction to complete a task. The teacher wrote the instructions and pasted them on his desk, but he did not follow them correctly and became involved in playing with his lunch box lid instead. The teacher then set a timer on his iPad to notify him to complete his work and asked him questions to encourage his participation, using private cues, such as talking over his shoulder, to ensure he was working. The timer beeped after every interval of 10 minutes, after which he had to stand up and show his work to the teacher. It was observed that an iPad that was placed on the student's table, set with a reminder that beeped after 10 minutes and that directed the student towards the task again.

Teachers expressed their belief that technology serves as an engaging medium and that multimodal features, such as text, audio and videos, help maintain concentration, focus and attention on the task. For instance, T5 noted:

> *"I can practice with them for longer due to the power of devices: either it is reading or writing. They are not as annoyed as they are in a regular reading or writing session. They have developed more interest in this practice and their reading-writing scores have improved as well."*

This comment illustrates that using technological features can also help overcome the frustration and anxiety of overthinking with regular writing and reading. This is important because when students invest more time and interest in a learning activity, it improves numerous skills, notably reading, writing, mathematical skills, and overall literacy, by directing their learning-related behaviours and cognition in positive ways.

A parent also mentioned the benefit of interactive writing practice when learning the Arabic alphabet, which, for his child, was not easy with paper-based exercises:

> *"His teacher contacted me to practice this alphabet writing exercise on this application 'Arabic Alphabet Teacher'. It is an easy application that allows him to find and recognise the alphabet in Arabic and improves his writing skills. It is fun and simple to use with attractive characters in it. I help and guide him to use his fingers to write the strokes of the letters on the screen. I do this multiple time and then allow him to repeat it. I keep observing him and, you know what, he manages to do it on his own. Otherwise, it was so tiring while practising on paper!"*

Participants agreed that facilitating regular practice and retaining the child's attention in regular learning efforts was important, but that it could be challenging. As a result, they valued the ease that technology-based practice offers and its ability to engage students in intrinsically repetitive tasks.

4.6.7.3 Improvement in self-regulation, organisational skills and impulse control

The teachers reported that a balanced instructional approach has the most potential benefits. They also expressed a preference for guided use of devices, instructing and monitoring students from time to time, because there are other behavioural issues associated with these students. For example, it was observed that students with ADHD who were exhibiting irregular and restless behaviour during classroom instruction, leaving their seats or wriggling in them, also exhibited an inability to engage and regulate themselves towards learning. When the teacher asked a question, they shouted out the answer before he had finished the question. They were also observed interrupting while other students were answering. At that point, the teacher brought in an iPad and turned on the application. The application's musical chime caught the attention of students with ADHD or autism, and they gathered around the teacher and followed his directions to settle in chairs. The music and interactivity of the application kept their focus on the task in front of them.

Teachers also believe that their own efforts to regulate, organise, and direct the students to complete tasks are important, because completing a task on a device requires specific steps to be followed. For example, it was observed that, to get the students with EFD into the mindset for learning, the teacher first gave them some crayons and paper. This was to enable them to become settled at the table and draw. When the students started to become distracted, they opened a drawing application on the iPad, and then followed the instructions. Sometimes they knew by themselves how to follow the necessary steps to use the application. For instance, they opened the application themselves, tapped on the pen icon, and then chose a colour using the paint icon. This indicates that the technology enabled them to be more focused, directed and organised towards the given task.

Furthermore, teachers reported that devices reinforce positive behaviour, helping students to overcome their impulsiveness through assistive features, such as rewards, which are built into many of the applications. For example, it was observed that a student with autism was highly absorbed in matching an object with its name on an application because he wanted to win the built-in incentive, which was a gold star and some stickers. This incentive kept him engaged and focused to reach the next level. This was contributing to his engagement and attention, as well as preventing him from becoming distracted. Thus, unlike traditional approaches to teaching and learning, the device was contributing to his learning repertoire, that is, developing his capabilities by learning names of objects and matching them with the corresponding image.

Moreover, this approach was further used to practice and drill certain tasks to reinforce and retain the skills or knowledge learnt. Teachers acknowledged that, while it was a challenge to keep learners with EFD engaged for long periods through instructions, using technology helped them develop self-regulation. For instance, T2 reported that:

> *"When learning through an application, their self-regulation is improved after certain trials of practice. Then they are allowed a certain level of autonomy, like to practice learning on their own. Because when they don't feel confined, and when they know they have their favourite device to do things, they feel independent. But it requires monitoring: they can be unpredictable with the devices. Their way of expressing excitement at times can be aggressive, such as banging the device hard on the table. But definitely in this whole process, they do learn many things in their desired learning styles, and we can check them by questioning."*

This demonstrates that electronic devices can stimulate students' learning patterns by improving their flexibility of thought, and that this is incorporated into the teaching strategy. However, flexibility and independence should not compromise learning, and the teacher expressed his belief that this approach should be controlled through frequent monitoring.

4.6.8 Key Findings

In summary, the following key themes were identified from the data gathered in Case Study 3:

- The adoption and selection of technological devices is based on their availability and the ease of access to them in the classroom;

- Preference for using a particular technology is further dependent on the affordances it offers to address particular EF difficulties;
- Participants prefer a balanced use of technology with traditional methods, applied in differentiated ways, based on a student-centred approach;
- Technology-mediated instruction is a motivator, reinforcer and collaborative tool for effective improvement of EFD, but there are some drawbacks;
- Differentiated instruction is adopted, with the incorporation of technology, as whole-class scaffolding. Practice and repetition are ensured under teacher supervision;
- Individualised instruction is also required, as each student is different, but this is not always achievable for students with EFD in an inclusive setting;
- Technology motivates the learning patterns of students with EFD by improving their flexibility of thought, but through constant monitoring and teaching strategies.
- Using automated technological features can also help overcome the frustration and anxiety of overthinking with regular writing and reading, hence contributing to learning of students with EFD.
- Therefore, technology serves as an engaging medium, and its multimodal features, such as text, audio and videos, help to maintain concentration, focus and attention regarding the given task.

4.7 Cross-case analysis

The results of the present study reflect the personal experiences of teachers and parents in using technology to support a range of students who have EFD. The findings indicate that, while their were some common experiences, all three schools adopt different instructional and technological approaches, and all differ in both the level of integration and the availability of devices and resources. However, there was general agreement that the integration of technological devices is advantageous in terms of the positive features these tools offer for students with EFD, notably their ability to engage and retain students' attention, and the way they encourage and facilitate practice and repetition. This appears to be due to students' affinity for visual media, and the multi-sensory and interactive nature of the devices, which allows complex tasks to be presented in exciting ways. This makes the learning process more straightforward for both students and teachers.

In all three cases, it appears that teachers perceive the role of technology as being facilitative and supportive in tackling students' difficulties. The different functions and features of the technology are considered promising by both teachers and parents in terms of improving of students' behavioural, cognitive, and academic performance. However, teachers also regard the role of instruction, guidance, support, and mediation as even more critical in addressing EFD, thereby justifying the focus on the role of scaffolding in the current study.

Teachers also identified student-teacher interaction, regular support and feedback as significant parts of their overall strategy. These elements are important; however, teachers perceptions regarding the value of technology appear to be affected by a lack of knowledge about the more advanced and profound affordances technology can offer to enhance the pedagogical performance of students with EFD. This knowledge gap may account for many of the challenges faced by teachers at different levels in realising the potential of technology. However, other inhibiting factors require technical and financial resources; these include a lack of availability, limited reliability due to interruptions to internet access or technical failure, and a lack of administrative and technical support.

The perspectives provided by the teachers and parents, their different ways of using technology, and their various strategies produced important insights in the context of this study; and these are presented in the cross-case analysis below.

1. *Knowledge about EFD:* The common finding in all three schools was the lack of participants' knowledge about the concept of EFD. The term "executive function difficulties (EFD)" was new to many participants, and they reported using the general terms "special needs students" or "students with learning difficulties" to describe a range of students who exhibited EFD-like characteristics. Teachers reported that neither the content of the curriculum nor any training had ever mentioned these difficulties as EFD, so they would never know if they were missing something like this. However, they were seen to perceive EFD as being similar to the challenges of students in different diagnostic groups, that is, autism, ADHD and dyslexia, which interfere with their overall learning and academic progress. This finding corroborates those of previous studies in that EFD and neurodevelopmental difficulties manifest shared impairments in various domains, such as social interactions, behavioural and cognitive issues (Antshell and Russo, 2019).

The knowledge gap regarding EFD is one notable finding in the Saudi context, as both general and special education teachers were aware of many underlying complexities that they noticed in these struggling students. However, their lack of exposure to content and details specific to EFD limited their ability to recognise that these complexities stem from cognitive difficulties referred to as EFD (Rapoport et al., 2016). The core focus of this study, that is, how technology addresses EFD, could not be determined entirely without the teachers' knowledge of EF being developed, followed by development of the educational role of technology and its relevant affordances in this context. Otherwise, teachers may hold many misconceptions about the use of technology or mixed opinions about prioritising its preference over other techniques, as found in all three case studies.

2. *Teachers' experience and technological expertise:* The main differences between the schools were in the experience of the teachers, and the use, integration, and availability of technology and other resources. Teachers in S2 and S3 were somewhat experienced, most having between eight and 13 years of experience. This level of teaching experience in the special education context is significant. All the teachers understood the importance of technology, but their use and proficiency with the technology and their awareness of the extent of its affordances was inadequate. This further indicates the need to develop their knowledge and understanding of technology, and in particular with reference to underlying research.

3. *Perceived Characteristics of EFD in different diagnostic groups*: The participants in all three schools perceived characteristics similar to those typical of EFD, such as exhibiting poor focus and inattention, extra effort to learn a new skill, lack of persistence with tasks, difficulty retaining attention, weak memory, lack of concentration, lack of control of behaviour, extra effort and action being required, disorganised behaviour and constant problems in maintaining focus. Respondents expressed their belief that the different diagnostic groups (autism, ADHD and dyslexia) all exhibit EFD-like difficulties. All the participant teachers differentiated between these students in terms of their specific LD. However, they lacked appropriate identification of students with EFD, and the term was new to them.

4. *Challenges identified:* These were also consistent across all three schools. The most common and prevailing challenge was a lack of professional training and development, which impeded teachers' abilities to understand the features and tools available to address EFD-like difficulties. Participants mentioned that they worked by themselves, using various methods (including

online tutorials, teacher networks and self-learning) to update their knowledge. Additionally, the lack of assistance to address technical issues teachers face in using technology was another crucial hurdle to consider. These findings align with those of existing studies that identify that teachers' understanding of EF is imperative, and that they identify the need for more training and development provisions in this context (Young et al., 2017).

5. The selection and use of technology: These were linked to compatible use, advantage and difficulty level for students, specifically in S1 and S2. However, in S3, teachers considered the use of technology depending upon its availability and facilities offered by the school. Projectors were used more in S3 than in S1 and S2, where smartboards and tablets/iPads were more frequently used. The availability of technology was inadequate in all of the schools, with many students and teachers bringing their own devices, such as iPads, to the classroom. This inadequate access illustrates the authorities' lack of integration of technology.

Consistent practice and routine with the applied tools and techniques are fundamental for effective EF skill development. This finding indicates that limited availability and the lack of required technologies to practice daily lessons can limit both teachers’ and students’ opportunity to practice. This finding aligns with findings of Dunlap (2020) who endorses that delivery of technology-rich lessons in a structured classroom environment directs active learning and response in students with EFD. Therefore, provision and availability of technology are imperative for active learning.

6. *A preference for technology relative to traditional techniques:* This was common in the more experienced and mature teachers. Some teachers in all three schools favoured blended use of both technology and the conventional approach, while some preferred the human element in teaching students with

difficulties, due to their belief that technology cannot replace instructions and traditional methods.

The results obtained under the primary research question measured participants' perceptions regarding the use of technology and different strategies that they adopt to use technology effectively. These findings constitute the central portion and contribution to illustrating how the role of technology and techniques used by teachers function to produce the desired improvement in different EFD-like difficulties. For example, introducing technology in practice wins students' attention and focus, further bolstering their efforts towards practising and remembering things, improving the pace of their cognitive control of inappropriate responses when technology is used as a reinforcer, and enhancing their self-regulation. For example, S1 includes mention of multiple features, sensory attributes and appealing tasks (through games and applications) available through technology for retaining attention, imparting independence and control (self-regulation) to the student, and directing their behavioural, emotional and cognitive engagement. Hence, this further illustrates that participants from S1 as being more oriented towards using technology's attributes to help students zone in for learning and then using frequent instructions and methods to teach them.

In this regard, participants in S2 mentioned the 'narrow transfer effect' of skills if they rely solely on technology. S3 teachers mentioned similar views, that is, that technology is just supplementary, and not a holistic solution. However, one S2 participant pointed to the ease that technology offers for repetitive practice and rehearsal, because students are given reinforcement and are motivated to learn through an interactive medium. Participants in S3 also expressed another view regarding the inhibitory role of technology, saying that students with learning challenges and EFD-like difficulties cannot rely solely on technology.

7. Distractions and unguided, prolonged use can have many negative impacts, resulting in technology's actual potential being lost. It requires patience, effort and time to use technology in a teaching session. Therefore, selection of the device has to be done extremely thoughtfully. They mention "*adopting a student-centred approach, that is, using a device that addresses their challenges accordingly.*" Although not directly assessed in the present study, the heterogeneity in learning levels and the EF characteristics of each student partially reflected the limitation in addressing the difficulties of each student using the same feature or function.

8. An important aspect identified under Research Question 2 relates to *strategies used by teachers to use technology effectively*. The case of S1 includes mention of teacher-student interaction at regular intervals, and constant support. Moreover, scaffolding and prompting questions were mentioned as potential approaches to verify that improvement is being made. S2 participants said that instructional scaffolding was a possible strategy, but not achievable due to a lack of assisting staff. A more group-based interactive learning session was practised, preventing off-task behaviour, and improving attention and overall learning time. Similarly, instructional scaffolding was practised in S3, using differentiated instructions to address the various difficulties of different students. These findings correspond with Vygotsky's concept of instructional scaffolding as a social process, guided by interactions with students using instructions and, in this context, technology, then shifting cognitive engagement from the teacher to the student.

The critical point assessed under this question was the perceived difficulty of assisting students with EFD using technology in a mainstream setting. However, the participants expressed a positive view towards the function of technology in collective and individual practice to engage and teach these students, although with some difficulty in reaching out to each student individually and giving one-to-one instructions. However, it was observed that they were limiting this by addressing students through group-based practice on devices.

It was also perceived that some EFDs were more challenging to address through technology than others. For example, with autistic and ADHD students, it was easy to engage and retain their attention towards a device showing a learning video or an exercise. However, it was a significant challenge to shift them to other tasks, to switch to a manual way of learning or to listen to the teachers' instructions.

The third research question pertained to understanding the *contributions participants perceived with technology* in addressing EFD-like difficulties. Participants from S1 mentioned technology's supportive/mediating role in directing students' challenging behaviour towards learning as a significant technological affordance. However, they also mentioned that the mediating role of the teacher, and the teacher's instruction, is imperative in technology performing this function. Participants from S2 reported that technology holds the potential for improving the organising and structuring skills of students who forget to organise and plan their tasks. Moreover, the interactive technological features allow them to take and remember notes more keenly. The data from S3 highlights primary technological capacities and contributions as 'improving academic readiness to learn, technology enhancing attraction towards learning’. It also highlights device attraction improving rehearsal time and collaborative sessions improving the learning capacities of students with focus, attention and memorising difficulties. As a result, these students' reading, writing, numerical and comprehension skills could improve.

A comparative view of use of technology across all three schools is presented in Table 4-7 below:

	SCHOOL 1 (S1)	SCHOOL 2 (S2)	SCHOOL 3 (S3)
Type and Use of Technology and Accommodations	• Devices: iPads, tablets, projectors • Games application (Puzzle games for group tasks) • Video stories • Video animations (learning action symbols) • Using iPads/tablets as facilitators for learning, for example, reading/writing (tracing) applications • Using devices as motivation and reward to reinforce a desired behaviour • Speech to text feature • Digital To-do-list • Scheduler/visual planner/calendar applications on respective devices • "To-do" lists/checklists with estimated times for each assigned task • Free versions of some reading/tracing and language applications (free with limited features/functionality) • Notification method: • Setting reminders with notifications on the student's device for homework and practice at intervals • **Challenges**: lack of Arabic versions of applications to practice specific EF skills.	• Devices: iPads, tablets, projectors • Using features of iPads, for example, for taking pictures of tasks and materials required • Record videos of instructions to help them repeat and memorise. • Using stylus on iPads/tablets to highlight and circle important points to remember • Digital checklists • Graphic organisers • MS Word to create checklist for material management • Digital file organisers and electronic organisers. • Reminders and schedules to reduce confusion and help remember deadlines	• Devices: iPads, tablets, projectors • Devices as engagement tools: Mainly used when students were least attentive or not listening to instructions • Showing videos to engage students • ADHD students were redirected with their favourite poems or games when they exhibited challenging behaviour or confusion • More focused on content and structures through charts and schedules in classroom • As reinforcement when students behaved well and did not break the routine or disrupt classroom activities (improved self-regulation)/ reward for completion of each task

Classroom Design and Accommodations	In S1, it was observed that teachers kept track of necessary arrangements to avoid distractions, for example, by making students sit near the back of the classroom to make it more difficult for them to look around and make distracting sounds. Classroom resources were labelled. There were cue cards and checklists to remind students to organise personal items in their desks and bags. Display of calendars and highly structured charts. To-do-lists were pasted on a notice board. Folders and baskets with important supplies were available to help plan and organise.	In S2, teachers arranged the seats of hyperactive and easily distracted students to be near instructional areas and the board. Few charts and calendars were displayed.	In S3, the arrangements were not maintained to address the needs of students with EFD accordingly. There was no specific arrangement to meet the inclusive framework. Students were seated haphazardly, which was distracting students
Note: See Appendix 1 for techniques, tools and intended outcomes used by teachers.			

Table 4-7: Similarities and differences in technological affordances and accommodations between the three cases

5 Chapter 5: Discussion

5.1 Chapter Overview

This chapter discusses the three case studies in light of the literature review and the theoretical frameworks described in Chapter Two and the research questions. It begins by considering their classroom settings and identifies the elements required to facilitate inclusive education for students with EFD in mainstream classrooms and the types of technologies used. It goes on to discuss the findings in relation to each of the research questions and the key themes which emerged from the data analysis. Some preliminary conclusions are drawn and initial recommendations made; however, these are developed in much greater detail in the next chapter, which sets out the implications for future practice and makes recommendations for teachers and policy-makers.

5.2 Creating an inclusive setting

All three schools were mainstream, inclusive schools facilitating the learning of SEN students, including those with autism, ADHD, and dyslexia, and other specific learning difficulties. The participant teachers were special education teachers with considerable experience in teaching students with various learning difficulties. Special education teachers in all the schools offered special classes for some students, for example, special reading, spelling and phonics sessions for students with dyslexia, typically in separate resource rooms. However, the findings illustrate a lack of collaboration and co-teaching between general classroom teachers and specialist teachers. Studies such as Mermelshtine (2017) emphasize that effective collaboration is essential for facilitating the success of both teachers and students, and closer collaboration in these schools could help to address the challenges of attending to each student individually, and enhance the quality of support provided.

In order to manage EFD effectively, teachers need to practice proactive scaffolding during the learning process, based on an assessment of students' respective learning needs (Vásquez Astudillo, 2020). In a classroom setting which includes students with varying levels of EFD, different levels of learning pathways are required, and this can only be realised effectively through the teachers collaborating (or co-teaching) (Alotaibi, 2017). Moreover, as these students spend significantly more time in general education classrooms than in resource rooms, closer collaboration between their teachers could help address their different behavioural and cognitive issues.

The variability in the characteristics of EFD students makes it difficult for teachers to make versatile accommodations for instructional design and learning practices; for this, they need to be trained to develop a greater understanding of these difficulties and how they can be addressed. In order to facilitate appropriate learning for students with EFD in an inclusive mainstream setting, teachers must be competent in executing strategies, curricula and interventions suited to the particular EFD. However, the findings of this study identify a lack of facilitations, accommodations and training facilities for teachers. This is in line with the conclusions of Alshenaifi (2018), who reported that facilities and necessary accommodations for the effective inclusion of students with cognitive difficulties in KSA are not yet standardised and require significant development, and suggests that much greater efforts must be made by schools and authorities to address this issue. The results of the current study indicate that this could be achieved by providing teachers with specialist training, both in respect of EFD and the affordances technology can provide, and by enhancing collaboration between general and special education teachers not only locally but internationally to have more holistic perspective. This builds on the findings of Al-Natour et al. (2015), who examined the Jordanian context and found that increased collaboration between general and special education teachers helped them to design better curriculum schedules, use methods more effectively, and make more appropriate learning decisions.

In addition to the experience and competencies of teachers, classroom organisation was found to have an influence on the practical learning of students with EFD. For example, in S2, teachers sat students with EFD near the front desk so they could monitor them more easily; however, in S3, such arrangements were not maintained consistently, making things more difficult for the teachers as well as the students. This finding aligns with studies such as Goodall (2019), who reports that the inclusion of students with difficulties necessitates classroom adaptations, and that a flexible classroom structure should be maintained that facilitates and eases the participation of students with multiple difficulties. In the context of this study, modifications in classrooms that could have facilitated the participation of students with EFD more effectively were inconsistently applied or missing completely.

In addition, the study found that the number of students in classrooms often surpassed the limit, making it challenging for teachers to address each student independently and manage them effectively. It also made it more difficult to attract and retain the attention of these students with a traditional instructional style. This is consistent with the findings of AlKhalidi (2014), who refers to the challenge of managing large numbers of students. In response to this situation, the instructional approach of the teachers in this study prioritised group-based approaches and 'peer tutoring' (Kurth et al., 2015). This approach enabled teachers to facilitate an individualised support strategy by pairing the students with EFD with more able students to serve as MKOs, as described in Vygotsky's social development theory (Taber, 2020).

Hallahan et al. (2020) identified the need for a modern pedagogical style that can address these students’ lack of attention and meet their additional needs. This requires a curriculum design and instructional layout which is versatile and aligned with their learning needs and difficulties. However, findings from the schools in this study indicate that only the national curriculum is used for these students, albeit in a customised form, and the literature indicates that this can disadvantage students with EFD when they are taught in inclusive classrooms. For example, Al-Mosa (2010) found that a centralised curriculum in inclusive schools limits the improvement of many students with learning and cognitive EFD. The findings of this study indicate that teachers made efforts to customise the curriculum to address the individual needs of each student, as a flexible curriculum supports the academic progress of these students, including by modifying the presentation and representation of content, utilising additional strategies, and incorporating content specific to students' learning and difficulties (Lee et al., 2006). However, in many cases, these modifications could not accommodate the needs and abilities of every student.

Overall, the findings have various implications for school leaders and policymakers in considering the development of an inclusive setting. They identify an urgent need to upgrade teachers' competencies, and to provide greater flexibility and accommodation, both in terms of school infrastructure and classroom layout, and in the curriculum, to enhance the inclusion of students with EFD.

5.3 Types of technology and its integration

In the Saudi context, efforts are being made on behalf of the MoE and related authorities to integrate technology in an inclusive educational context to give equal opportunities to both general and special education students (Allmnakrah and Evers, 2020). The findings of this study demonstrate that different technological tools and devices were used to improve learning across the three participating schools, notably iPads, tablets, computers, projectors and smartboards. As this study demonstrates, modern technological devices such as these are influential in promoting learning in students with learning difficulties. However, as Rachanioti et al. (2019) note, for the practical application of technology and the cultivation of an environment in which students actively engage in the technology-assisted learning process, devices must be readily available. The analysis of the provision and integration of technology in all three schools revealed a gap in this regard, meaning device use was insufficient to facilitate learning for students with EFD, mainly due to the limited number of devices available for each class. Although many students had their own iPad/tablet, and some teachers had laptops/iPads in S2 and S3 during collaborative or individual sessions, it was not easy to practise individual lessons. Other limitations were lack of required applications for practicing EFD specific practices and most of the available applications were in English. This finding echoes previous studies which relate this inadequate availability of devices to teachers' inability to realise the potential of technology (Vallance et al., 2009). However, other constraints were also identified by the teachers, including the absence of Arabic versions of applications and software, the lack of classroom assistance to help individual students use the devices, and various technical issues, including a lack of specialist support and inconsistent internet access. They also regarded teacher mediation as highly significant.

The findings of this study therefore identify a lack of access to devices for students in each classroom as a significant limitation on the effective integration of technology, as most students and even teachers were required to bring their iPads or tablets to school. Additional improvements in staffing and infrastructure are also required to enhance their usefulness and reliability.

The following sections discuss the findings in relation to each of the research questions established for the study.

5.4 Research Question 1: *To what extent are parents and teachers aware of the concept of EFD in Saudi schools?*

5.4.1 Awareness and knowledge of EFD in using technology

Previous studies have often focused on how EFS can be developed through different interventions and strategies and on understanding how developing these skills can help students in the academic domain. However, little research has considered the importance of awareness and knowledge of EFS/EFD in relation to using technology effectively to develop these skills. Studies that have brought this concern to the forefront have done so simply at the level of general information, without examining the factors that contribute to the lack of knowledge and awareness of EF in detail. This section therefore explores the themes that emerged within the findings in this regard, and discusses them in the light of previous literature.

5.4.1.1 Lack of EFD awareness and knowledge

The information obtained from the present study indicates a lack of knowledge and awareness of EFD as a concept among the teachers in all three schools. However, their responses indicate great familiarity with and understanding of the underlying challenges of students with EFD, such as memory issues, inattention and lack of focus, lack of impulse control, shifting from task to task, weak memory and memorising abilities, and insufficient self-responsibility, self-discipline, and organisational skills. While all participant teachers were qualified teachers who had been teaching special needs students for several years, their lack of knowledge may relate to the fact that the participant teachers were general education teachers with diplomas or courses in special education.

The above is linked to the importance of the teacher's role in developing EF skills, as Burgener (2019) states that teachers are frontliners in practising skills with students, holding the greatest responsibility for addressing challenges, and thus requiring a thorough understanding of these intricate challenges. This calls for the design and implementation of a training and development framework to include the importance of awareness of EFD because, despite teachers potentially having years of teaching experience, there is a gap in understanding related to this concept.

The findings of the present study are consistent with the findings of Morgan-Borkowsky, (2012), in that teachers were found to be inconsistent in their understanding of EF and their perception of these skills as important for the better performance of students in class due to a lack of relevant resources. This is important because teachers with limited knowledge about EF as a neurological development component and construct cannot be expected to possess the relevant competencies and insights to develop the EF skills of these students to enable them to reach their developmental milestones. Nor will they have the requisite knowledge and awareness about the complex cognitive function associated with EFD to design an effective curriculum on an ongoing basis.

Lederman and Torff's (2016) findings concerning teachers who lack knowledge and awareness of EFD show that effective instructional design requires knowledge about these difficulties at the individual student level, with teachers making modifications depending upon the difficulties these students experience. Using previous content knowledge to modify the curriculum in a simple way at the beginning of the session is not an effective approach, and would not result in an effective instructional programme. This emphasises the importance of teacher knowledge of EF, of detailed insights into EF processes, and the subsequent configuring of learning and teaching strategies. A lack of awareness of EFD therefore limits the capacity to design effective strategies that support the development of EF capacities in students with EFD.

These findings raise the question of what influencing factors may have led to teachers' awareness and knowledge of these important skills being undervalued. As the teachers mentioned, their understanding and knowledge is hampered by the limited provision of training and professional development opportunities. This relates to the viewpoint of Laski and Dulaney (2015) that teachers' perceptions of the importance of these cognitive processes relates to how much they have experienced students with EFD throughout their teaching careers and their engagement with cognitive research that highlights executive functions specifically. This illustrates the need for the MoE and other relevant education authorities to understand why research into EF skills, and the educational practices which promote them, is important for teachers, and how their understanding and knowledge of these issues enhances their ability to support students effectively in the classroom.

In addition, as Long et al. (2016) point out, teachers who lack specific knowledge about EFD difficulties may have limited knowledge of the student's learning needs, and may thus be unable to contribute to their learning trajectory. This study reveals that a range of different techniques and interventions were used in the case study schools, with teachers selecting one or the other based on its availability, their understanding of its affordances, and their assessment of the needs of the students involved. However, Keenan et al. (2019) identify lack of training and resources as contributing factors that limit teachers' understanding and knowledge of EFD. This signals a need to investigate the effectiveness of the methods teachers employ to teach students with EFD using technology. However, the more serious concern is that this lack of awareness limits teachers' ability to recognise the importance of addressing the cognitive difficulties associated with EFD or their interrelatedness. The findings also reflect the gap in efforts by the MoE and school authorities in developing training content which provides background information about EF and the use of appropriate interventions to address it. This is discussed in more detail in section 5.8.1 below.

The prevalent lack of knowledge about EF among parents limits their ability to support their child effectively and to play the cooperative role required for improvement and learning. The teachers in this study identified a lack of parental cooperation in determining appropriate procedures and practicing tasks at home, as well as a lack of knowledge about the difficulties faced by the child, as significant barriers, and this is in alignment with the views of Đurišić and Bunijevac (2017), who state that the parental role is as important as that of the teacher in respect of their knowledge and awareness of EFD. The cooperation of parents with teachers is equally important in helping them access ideas and information on how they can best assist their child in a non-academic context, such as the home, and enable them to generalise the skills they have learnt at school. Furthermore, Wilson et al. (2018) posit that a more knowledgeable parent would exhibit appropriate parenting behaviour and sensitivity to their child's learning needs, enabling them to stimulate the child's interaction by knowing what suits their child best and engaging them in the right way. Thus, better parental understanding of these issues would enhance parents' facilitation of learning at home, and their ability to act as an appropriate learning guide with regard to both curriculum-related activities and the transfer of knowledge.

The importance of teacher and parent awareness of EFD relates to the fact that EF skills involve diverse cognitive skill processes which are integral to academic achievement and regulating behaviour. They also provide a critical predictive factor for the daily functioning of students. It is, therefore, critical for school authorities, and even the MoE, to develop opportunities for learning and knowledge leverage for teachers in mainstream inclusive settings, and that parents should also be part of these learning steps. This urgently needed development would bolster EF knowledge in both teachers and parents and help them understand how to direct their efforts to address students' challenges more effectively. Owing to the significance of the EF construct teachers in particular need to be aware of the multiple aspects it encompasses, in order to identify the right equipment and approaches to meet the needs of students who exhibit varying degrees of with EFD.

5.4.1.2 Identification of EFD and perceived characteristics

A common trend across all three schools was that participant teachers and parents perceived that students with heterogeneous challenges in different diagnostic groups (namely students with autism, ADHD, and dyslexia) had characteristics similar to EFD which contributed to their challenges both at school and home. Teachers also held the view that these cognitive difficulties are an integral construct that relates to the academic well-being of those students. However, this awareness of EF skills was obtained through their own teaching experience with learning difficulties, rather than through any training specific to EFD. This suggests that teachers come to learn about different aspects of students' difficulties and make assessments of their needs based on subjective experience rather than formal training.

The identification of these students through their specific learning difficulties was common in all three cases. However, teachers indicated that developing such skills requires extensive effort and time in an educational context. This is compounded by a lack of standardised assessment and evaluation criteria to determine the EF characteristics of these students. Thus, although teachers were familiar with the difficulties exhibited by these students and their impact on academic success, the term “executive function difficulties (EFD)” was new to them, and they lacked appropriate identification for such students. While this can be addressed in current teachers through the provision of additional training, the move towards more inclusive education practices in Saudi educational context indicates that the authorities responsible for initial teacher training and supporting novice teachers may also need to incorporate EFD, and interventions to address these challenges.

5.4.1.3 Perceived characteristics of students with EFD

Due to a lack of knowledge or a concrete definition of EFD, teachers typically identified EFD in students as 'poor focus and attentional control'. Many participants perceived that these students needed to make extra effort to learn a new skill, had problems initiating a task, showed a lack of persistence with tasks, and difficulty retaining attention. Another common perceived feature revealed in the findings was disorganised behaviour and constant difficulties in maintaining focus. Teachers identified EFD-like characteristics mainly in autistic and ADHD students, as they frequently exhibit distraction, lack of focus and hyperactivity, which reduces their academic achievement. However, once the concept of EFD was explained to them, the teachers related the inability to remain consistent and calm in students with ADHD to EFD, and identified their lack of ability to control their impulsiveness as a cause. Similar issues and symptoms perceived to be features of EF in ADHD have been reported by previous studies, e.g. Craig et al. (2016).

In addition, teachers recognised that the difficulties students with autism experience in switching from task to task is associated with the cognitive flexibility area of EF (CF). Teachers also identified that an inability to remember tasks or important schedules relates to weaker WM in students, and that the hyperactivity and impulsiveness in students with ADHD related to a lack of self-regulated behavioural, organising, and planning abilities, which are core elements of EF skills. Furthermore, teachers perceived that the inability of these students to reduce their disruptive responses and their frequent switching from task to task is associated with poor impulse control. Another important aspect mentioned by these teachers was that it is difficult to motivate these students to learn, and to prompt them to improve and optimise their performance; they need some tangible reinforcement and immediate feedback or reward. This has been identified in previous findings by Prins et al. (2013), who mention the role of reinforcers and immediate feedback or reward in moving direction and attention towards learning behaviour in students with cognitive difficulties, and specifically with ADHD.

Some teachers also reported students with dyslexia exhibiting issues of poor memory associated with their inability to read and write. The findings of the present study also demonstrate that teachers were able to identify difficulties in memorising (WM), CF, and IC as being related to writing skills in students with dyslexia. They saw that weaker WM limits these students in terms of recognising a word and matching it with the representation of the word in their mind, impaired CF undermines their capacity to think in different ways in order to express their thoughts in writing, and poor IC limits their use of appropriate words and phrases, making writing a frustrating and complicated process.

The perceptions of teachers and parents of the expected characteristics exhibited by different diagnostic groups, such as those with ADHD, autism and dyslexia, also relates to the phenomenon of comorbidity and co-occurrence of EFD in different diagnostic groups (Craig et al., 2016). The findings indicate that substantial co-occurrence of EFD exists in these students, and it is well-documented in previous studies that these groups are the most commonly and frequently diagnosed as exhibiting EFD (Demetrious et al., 2018; Filipe et al., 2021). It was beyond the scope of this study to determine whether the varying levels of EFD and its commonality in these neurodevelopmental groups have links to the varying levels of ASD, ADHD or dyslexia; however, it is clear that the characteristics of these students differ, with each of them having unique EF characteristics. As these unique profiles have an impact on successful writing, reading and overall learning, and considering the lack of expertise and knowledge identified in this study and elsewhere, it is important to contribute to teachers' and parents' understanding of the cognitive mechanisms (related to EF) that underlie the development of academic skills.

To conclude, it is important to emphasise the implications emerging from the findings in the context of developing EF-related knowledge, content and training for teachers to address the multiple and diverse needs of students with these difficulties. Although teachers and parents recognise that the behaviours that characterise EFD are present in different students with learning and intellectual difficulties, they cannot address them effectively until they can identify and understand the underlying causes. This requires awareness of EFD as a specific construct that may exist as a comorbidity or independently in students.

The next section discusses the findings which address RQ2 in light of the literature.

5.5 Research Question 2: How is technology being used to support students with EFD in Saudi schools*?*

EF skills involve cognitive processes, and the adoption of varied cognitive teaching practices and interventions has been found (theoretically) to result in specifically targeted EF gains. This section reflects upon the findings of this study in relation to RQ2 and discusses the various ways through which technology was selected and used to achieve EF gains by these teachers and parents. In particular, it considers the major themes that emerged from the findings, including a preference for using technology via a balanced approach, game-based approaches, using technology as an aid, and for repetition and practice to improve EF skills.

5.5.1 Selection and use of technology

Research suggests that where technology is used to enhance learning for students with EFD (Schwartz, 2014), the adoption and selection of devices is largely based on their availability and accessibility in the classroom (Lawrence and Tar, 2018). However, previous studies also mention ease of use from a student's perspective, in that the technology is easy for them to use in learning (Courduff et al., 2016), and Otero et al. (2014) state that the selection of technology depends on the ease a device or tool offers regarding practice and how much it motivates students to commit their efforts towards learning.

The findings of this study identified differences in the selection criteria between the three schools. In some cases in S1 and S2, the use of technology was linked to its compatibility and relative advantages. Thus, selection preference was based primarily on instructional ease, engaging multiple senses (through seeing, hearing and touching) at the same time, and allowing the participation of many students. The selection of a particular device was further based on its ability to facilitate the active participation of students altogether, such as by using a projector screen for its large screen interface. In contrast, in S3, selection preference depended on the availability of devices, familiarity, and access. Due to a lack of access to other technologies, many teachers favoured the projector, as some students practised tasks on their iPads/tablets, it was convenient for teachers to use them more frequently.

In addition, Diamond (2012) considers students' age and current developmental level as essential considerations before selecting and using technology for students with EFD. However, the interviews and observations conducted for this study indicated that the selection and use of technology in these schools was determined by the teachers' experience and expertise with a particular tool, rather than the students' ages and current developmental needs. This may relate to the notion expressed by Bradley et al. (2015), which is that reluctance in teachers to use and integrate technology into lessons more frequently relates to their previous experience with technology and digital interfaces; however, the findings here indicate that even those teachers with technical knowledge and experience did not have right expertise and skills to determine suitable interaction patterns and student engagement.

5.5.2 Preference for using technology

The majority of participant teachers considered technology as another learning tool that may augment and enable learning for students who require more effort to teach or cannot be engaged with only traditional techniques. Although they have adopted technology, they prefer to integrate it with traditional approaches or techniques to address the multiple difficulties of the EF domain. While they acknowledged technology's capacity to transform avenues for learning by enabling the engagement, motivation, and facilitation of learning for these students, they also viewed teacher mediation as extremely important. (See 4.4.8.2). However, a lack of adequate classroom assistance limits teachers in how much they can reach out to students individually.

5.5.2.1 Combination of technological and traditional approaches to address EFD

There seems to be a common understanding in all three schools, which relates to designing a balance of complementary approaches, integrating both traditional methods and technology. Findings from the present study indicate that integrating technology with other approaches facilitates learning that offers multiple means of representation, as well as multiple choices for student engagement and expression. This affirms the perspective of Meyer et al. (2020) that providing multiple modes of learning experience to students and giving them versatile choices enables them to connect to their interests and to experience better comprehension and learning experiences.

However, literature also suggests that teachers' ability to integrate technology with traditional techniques may be influenced by factors that prevent them from using the technology as intended, such as a lack of formal training in using technology (Courduff et al., 2016), a lack of ongoing technical support, and using technology only when students are seen to be losing interest or engagement. These constraining factors were observed in all three schools, and are discussed in more detail below (See 5.6.4); however, despite these challenges, the present study found that teachers were positively disposed towards the integration of technology, owing to the facilitation and motivation it provides to engage students and enable improvements in their EF skills.

The preference for using technology along with traditional approaches is also related to the fact that technology, being an ancillary tool like any other facilitative tool, cannot be a total replacement for teaching itself. The findings illustrate that teachers believe in maintaining the academic dimension of learning and teaching by incorporating both approaches into their daily routine for students with EFD. This idea underlines the importance of teachers' instruction and guidance, and aligns with the view of Dimitrios et al. (2020), who stress that the active participation of teachers, their verbal instruction, guidance and monitoring, is essential to maintain the pedagogical concepts of curriculum activities for students. Relative to this, using a balanced approach also relates to teachers' concerns that excessive technological integration would create a digitalised and mechanistic way of learning that would lack many important aspects of traditional methods. This includes, for example, the depth of understanding developed through the active engagement and interaction of teachers and their roles as MKOs, appointed as the key agent in enabling students to reach their ZPD.

The teachers' preference for a balance of instructional and technological approaches is also supported by the position of Huber et al. (2018), who highlight the importance of teachers' instructions to enhance the effectiveness of visual tools on devices (e.g. graphic organisers, note-taking applications, reminders). This notion provides further evidence for the belief that students with cognitive difficulties are more likely to engage with visual content that stimulates their engagement if they have appropriate teacher support. In addition, Hansen and Richland (2020) propose a similar idea, asserting that providing simultaneous visual representations of concepts can enable better understanding, and in particular development of more complex mental models of understanding, if adequate support is in place. Within the context of this study, adequate support during learning can enable students with EFD to notice critical correspondences and ignore irrelevant features, particularly while solving complex problems.

Previous studies which have endorsed a balanced approach to learning have highlighted the multi-sensory nature of technology, which the teachers in this study also valued. For example, Noreen et al. (2019) report that conventional teacher teacher-centred approaches which rely on verbal instruction without any potential involvement of the senses, do not make learning an attractive or engaging activity for students. They suggest that learning is motivated more when all senses are activated, notably through interactive and visual media. The findings from the present study show that teachers often integrated technology to engage students' senses when they were not paying attention or struggled to focus on traditional techniques unless technology was used. Thus, in this context, using a mixed approach allows students with EFD to have a hands-on, multi-sensory experience by practising technology-related tasks and developing reasoning skills and cognitive flexibility by connecting abstract ideas and theory with interactive content.

5.5.3 Using technology to aid instruction in order to ameliorate EFD

The importance of using instruction is related to Vygotsky's notion of language's importance as a cultural tool for learning which is central to social and cognitive development (Vygotsky, 1962). Moreover, as relates to developing EF skills in the academic trajectory of a student, verbal instruction has significance within classrooms (Schwarz and Baker, 2016). However, these instructional dialogues should entail reasoning and elaboration to enable students' reasoning and cognitive development. In terms of using technology to facilitate, motivate and supplement the use of instruction in teaching and learning, the present study's findings are analogous with those of Sinnari et al. (2018). They highlight the need to use technology in combination with existing techniques to facilitate instructional delivery and augment interventions and approaches to achieve maximum impact. The effectiveness of technology is also related to how efficiently it facilitates learning for students and how it is used, particularly through student-centred learning (Vásquez Astudillo et al., 2022). This indicates that the effective incorporation of technology is linked to teachers' pedagogical and content knowledge, and their knowledge of the technology and its affordances. However, the findings of this study demonstrate that teachers had little context-specific knowledge to guide their use of technology to address EFD although they knew it was effective and used it in their daily lessons to support instruction.

The technological function of providing a reinforcing, motivating medium to students was the most critical potential function reported by teachers in all three schools. Students with EFD, specifically those with ADHD and autism, often exhibited challenges in remaining motivated and engaged in learning, paying attention, focusing on the task, and remembering details of the activities assigned to them. They required multiple reminders, and the use of external prompts or reinforcement to engage with some tasks, and their lack of engagement and concentration also increased their confusion when they were required to follow multistep directions to perform a task. However, using technology as a facilitative aid to keep their instruction interesting, was found to be effective with these students, largely due to its motivational aspects. Previous studies have demonstrated that reinforcement for students with cognitive difficulties is strongly linked with levels of motivation, with preliminary evidence indicating that an uncommonly low motivation towards learning a task accounts for performance challenges in these students (Cartwright et al., 2020). Hence, they cannot easily be encouraged to stay on task through regular reinforcement, but instead require different types of reinforcement, including instant rewards. The findings of this study illustrate that using technology for reinforcement, with its immediate feedback and clear rewards for improvement, kept these students on task and learning for longer than less pronounced or delayed types of reinforcement.

Another aspect of technology's role in assisting instruction is its ability to facilitate dialogic collaboration or pedagogical styles. Based on these teachers' use of a balanced approach, or the use of interdependency in instructional pedagogy, it is clear that using technology as an intermediary along with instructional scaffolding and time to time teacher's guidance can create a supportive and productive learning context i.e. helping them direct their WM towards a learning task on an interactive medium with low cognitive load(with appropriate design specifications)that further limit direct their inhibitory control through less distraction on digital device.. This synchronous learning approach develops a learning context that is not limited to talking, but builds ideas collectively by developing reasoning through an interactive medium. This idea has connotations related to Vygotsky's conception of the role of language as a cultural tool in the learning context of social cognitive development (Vygotsky, 1980). It further reflects the importance of dialogue and instruction in developing the academic trajectory of students with difficulties, as endorsed by studies such as Schwarz and Bakers (2016) and Major and Warwick (2019).

The perceptions held by teachers and parents across schools regarding the role of interactional and technological learning relate to the notion that instruction plays a central role in cognitive development, as it influences meaning-making (Calcagni and Lago, 2018). Technology, through its multiple sensory aspects, engages different senses and develops a shared dialogue space between teachers, students and peers. In particular, using iPads and smartboards enables the use of multiple sensory approaches and media multitasking, that is, listening, touching and observing the screen simultaneously, and rehearsing activities on the screen. This improves students' academic capacities in comprehension, critical thinking and reading. Moreover, multimodal affordance enables flexibility in the delivery of instructions and learning resources.

5.5.4 Group based interactive learning sessions to address EFD

Using technology to collaborate and learn through gaming techniques has been established as an effective tool to develop EF skills more efficiently (Cardoso-Leite and Bavelier, 2014; Blumberg et al, 2019; Plass et al, 2020). This idea was found to be prevalent among teachers and parents at all three schools as a way to help students with EFD to regulate themselves in collaboration with a more competent partner in a group setting. This group-based peer collaboration directly relates to the concept of involving an MKO in a learning activity, which underpins Vygotsky's paradigm of cognitive development through social interactions.

The findings indicate that this practice was common in all three schools, firstly because teachers found it to be a potential substitute for one-to-one instruction due to lack of staff. Secondly, small, peer-based collaborative activities involving verbal discussion and observing each other, sometimes on a laptop or even watching videos together on the projector, were believed to be effective. This is consistent with the view of Vygotsky and Piaget that collaborative interaction is a foundation for cognitive development. This is, furthermore, in line with Vygotsky's *intersubjectivity,* that a collaborative group activity allows individuals to collaborate and share different viewpoints to reach a shared understanding through the completion of tasks that place demands on cognitive abilities (Cannella, 1993).

It is evident at various points in the findings from S1 and S2 that teachers grouped and paired students with their classmates to maintain guidance and monitoring throughout when they could not reach out to each student themselves. This was further enhanced through discussions and reasoning, in the same way that Sills et al. (2016) report that collaboration, if mediated by active participation, discussion and verbalisation of different opinions, allows problem-solving and cognitive skill development in students with typically weaker cognitive performance.

Riccio and Gomes (2014) have put forth analogous perspectives, since they have discovered that interactive sessions conducted in a group setting exhibit similar characteristics with instructional strategies. In addition, Moeller's (2019) findings show that this reduced the disruptions in learning and allowed quality engagement of students with their learning partners. Moreover, a minimal amount of resources were demanded. The results of this study align with the findings of Rothlisberger et al. (2012), who similarly observed enhancements in WM, IC, and CF following a six-week intervention including group-based engagement in various activities.

In addition to the above finding whereby interactive group sessions and collaborative learning appeared to regulate EFD, exchanges of expressions and reciprocity were also observed to some extent, e.g., the smiles and happy expressions on students’ faces (see heading 4.4.8.2) This dimension demonstrates that developing technology-mediated practices has the potential to influence and regulate ToM-related aspects in students with EFD. The findings of the current study show that students with EFD are more likely to show improvement with regard to these aspects via technology-mediated learning. The expressions and feelings of happiness after scoring a goal in a game or, as on another occasion, showing a smile when hearing their name on an app, demonstrate improvements in their emotional recognition, followed by self-expression, which relates to and contributes to the development of aspects of ToM as identified by existing studies (Pellicano, 2007; Torske et al., 2018). These examples concern an individual’s capacity to express mental states to others, such as beliefs, desires, intentions, and emotions. It may be inferred that children with EFD may also exhibit enhanced ToM-related abilities even in the absence of explicitly technological mediation targeting their EFD. This outcome is likely based on the substantial reinforcement and emphasis placed on reciprocity, which were relevant features of the technology-based improvement in their EFD.

This evidence demonstrated that the function of ToM is also strongly associated with other cognitive processes, including memory, observation, cognitive flexibility, and the ability to inhibit. The interlinkage of EF and ToM was further evident while they (children with EFD) were able to practice an interactive task individually, or a game-based collaborative activity which involved turn-taking. In the latter instance they exhibited inhibitory control to take turns, which is essential for simultaneous consideration of one's own perspective and the views of others, and further links to the cognitive and social advancement of ToM (Torske et al., 2018).

The research shows that using technology to help with interaction can be a good way to get students with EFD involved in different learning activities.

Furthermore, their engagement with both peers and teachers through this interaction facilitates the development of metacognitive skills, ultimately enhancing ToM-related aspects (Milligan et al., 2008). By engaging in these processes, opportunities for improving their proficiency in comprehending diverse viewpoints are created. This is further enhanced by the verbal guidance provided by teachers, followed by the expressions of the students with EFD, either verbally or non-verbally, which involve articulating their own cognitive states and responding to those of others (Brock et al.,2018). Therefore, this dimension, i.e., how improvements in EFD through technology mediation can direct ToM, needs to be further explored and should be of substantial interest for future research. Future research could delve deeper into specific neurodevelopmental conditions such as ASD or ADHD, so as to better understand the functional link between ToM and EFD, and how technology may mediate in the process of addressing EF- and ToM- related issues.

Previous studies related to the nature of theory of mind (ToM), have demonstrated that ToM involves a complex cognitive process that includes making inferences and predictions (Mitchell and Phillips, 2015). It is not merely a straightforward transmission of information from one individual to another. ToM involves evaluating behavioural cues and drawing conclusions based on them. Research has revealed that the cultivation of behavioural synchronization offers potential avenues for facilitating the accurate understanding of others' cognitive processes. In addition, the rapid development and integration of technology in various forms in educational processes have been found to improve higher cognitive processes, including ToM (Drigas and Karyotaki, 2019; Drigas and Pappas, 2017). In light of the findings of the current study, it can be understood that group collaboration, as well as learning through applications and learning games, exemplify the potency of behavioural synchronization, particularly through the use of technology (Bamicha and Drigas, 2022). This is because cooperation and collaboration in this way have a crucial role in reducing the psychological and mental gap between individuals, leading to increased attention towards others and their cognitive processes, hence facilitating their interpretation. Therefore, this highlights another direction for future studies to build on the knowledge of how technology can be utilised more appropriately to synchronize the behaviour of students with EFD and improve the gaps in ToM.

The existing body of research has produced substantial evidence that establishes a connection between EF and ToM (Best et al., 2009). According to Brock et al. (2018), EF is a key determinant of ToM, and an integral component of overall cognitive functioning, where its primary function is to facilitate the identification and understanding of mental states (Leslie et al., 2004). In addition, a number of developmental psychologists have also argued about the fundamental link that exists between EF and ToM, and how this link influences the development of one domain and the emergence of another. Significantly, it has been asserted that the development of ToM is a necessary condition for children to effectively regulate their behaviour, specifically their EF. Conversely, Russell (1996) proposed that the acquisition of EF, particularly the ability to control one's actions, is a prerequisite for the subsequent development of ToM.

The theoretical underpinning of EF development on the development of ToM asserts that changes in ToM, either developmental or individual, are closely connected to their cognitive functions such as self-monitoring, working memory, attention, programming and cognitive flexibility, which further influence their ability to pursue goals. Hughes and Leekam (2004) assert that EFD has a significant impact on social interactions, ultimately influencing the understanding of the mind.

Determining the developmental path of EF components and their correlates during middle childhood has the capacity to provide insights into practical and theoretical issues, such as TOM (Bock et al., 2015; Best and Miller, 2010). The existing research base primarily concentrates on the preschool years when examining EF and ToM, and some studies have demonstrated substantial variations in developmental advancements over the period in young individuals (Garon et al., 2008; Devine and Hughes, 2014). This emphasis on preschoolers primarily may be due to the fact that throughout a child's transition to kindergarten, EF necessitates the ability to inhibit one's working memory and regulate impulsive responses in order to consider other perspectives. Moreover, EF abilities have a mediating role in the rate and efficiency with which children acquire ToM. EF performance measurements predicted later ToM false belief task performance (regardless of age group, verbal competencies, or earlier ToM performance scores), according to a number of longitudinal studies on the EF-ToM link in early childhood with typical development, but not the other way around (Rakoczy, 2022). These studies indicate that EF is an early determinant of ToM development because it scaffolds ToM processes. Further investigation into the developmental relationship between EF and ToM in school-aged children across various neurodevelopmental groups remains unknown due to the failure of this theoretical perspective to consider potential associations beyond the fifth year. Therefore, there exists a noteworthy knowledge gap regarding EF and ToM in individuals older than five years of age. The limited longitudinal research on school age has shown weak evidence that early ToM predicts later EF, but stronger evidence that early EF influences later ToM. This suggests that EF may fundamentally affect children's development, particularly in relation to social cognition (Austin et al., 2014).

Moses (2001) and Russell (1996) elaborate on the impact of EF on ToM in two ways. Firstly, EF may affect the manifestation or expression of ToM. Secondly, EF may influence the development or emergence of ToM. In the realm of cognitive development, it is widely acknowledged that children possess mental-state notions. However, their ability to effectively communicate these concepts is often hindered by the executive demands inherent in the tasks employed to assess such abilities.

Therefore, the findings of the current study raise a crucial question to be explored by future research in terms of understanding the underpinning proximal mechanisms of how EF influences the emergence of ToM. The findings further indicate the relevance of exploring how EFD and ToM associate with each other in different neurodevelopmental groups, and how the role of technology can be directed to improve this link for the better learning and academic progress of these students. As delineated by prior scholarship, the proximal mechanisms entail the influence of EF in facilitating the coordination of different perspectives and in recursive reasoning, but more research is needed to outline these proximal mechanisms with the use of technology that may further enhance behavioural synchronization and EF-ToM associations.

5.5.5 Game-based learning to regulate EFD

The use of serious learning games has been identified as a potential means of developing sustained attention, WM, and impulse control (Sújar et al., 2022), and an interactive interface using games was found to have potential in stimulating different EF skills in students across all school contexts. For example, in S2, a collaborative session on the smartboard involved a memory matching involving fruits, colours, shapes and requiring students to memorise the names of items. This encouraged the attention and engagement of the students for a longer period, with constant monitoring and instruction from the teacher. The teachers also use games that involve mathematical tasks, such as practicing subtraction and addition, and reported that they enhanced numeracy skills in ways that could not be accomplished through other methods. Improvements in reading skills were also engendered by different game features and applications that helped students memorise the name or sound of a letter, with the ability to pronounce new or unknown words enhanced through tests, retests, and constant practice. This is consistent with the views of Sinnari et al. (2018), who argue that games-based training improves cognitive capacities for participants, firstly directing their learning behaviour by engaging their attention and then positively influencing different academic skills.

Using multimodal gaming features was perceived as engaging students and utilising their executive control capacities through different features and tasks, such as WM, reasoning and IC. This illustrates the role of games in supporting perceptual and cognitive skills, as reported by the teachers and observed in various gaming sessions practised both independently and in groups. Independence in making selections in different gaming features improves attention through selective attention tasks, and audio and visual notifications keep students engaged and enables them to process the commands that facilitate memory, attention, sensory integration and thinking skill. The application's interface also has implications for attention due to it being subjectively pleasing and easy to use for long periods.

These findings illustrate that game-based learning improves EF skills, but they do not determine whether transfer of these learned skills occurs in other contexts. Thus, it is unclear whether improvements applied only within the context of the interface or programme on which they practised, or whether the skills had been internalised and would be improved in other contexts too. Hence, it can be understood that while game-based interactive practices were perceived to be effective in decreasing attention difficulties, and improving memorisation abilities and WM through better focus and IC, the evidence on the maintenance or broader transfer effects of game-based improvement in EFD is less substantial.

5.5.6 Repetitive practice with multiple content and tools to improve EFD

An important finding from the study, illustrating the potential of technology in developing EF skills and overcoming other cognitive difficulties, is its ability to offer repetition and practice of tasks in ways that are more engaging than traditional approaches. Using technology-mediated learning through apps or games helps students with EFD focus for longer and sustain practice until they achieve positive results. This is in line with previous studies which have reported the power of repetitive practice and rehearsals to improve and retain EF skills. For example, Dunlap (2020) suggests that EF skills are trainable, and that practising tasks repeatedly further contributes to improvement in students' academic performance in areas that require high-level reasoning and cognitive flexibility, such as mathematics, problem-solving skills, and reading comprehension skills.

The common finding in all three schools was that teachers believed in practicing and rehearsing a task to retain gains and improvements. In addition, the efficacy of practice and repetitive trials to enable students to develop their level of competence and traverse the ZPD, to the point where they can perform tasks unguided, has been acknowledged (Otero et al., 2014). Adopting a technological medium for this purpose has significant potential, as accepted by teachers in all of the schools, because the technological medium provides ease in increasing the level of challenge through games and interactive tasks that are interesting and engaging for students to practice. As one teacher in S3 expressed it, "the rehearsal of tasks can be done through technology in an interesting way that facilitates cognitive and behavioural function." The view that technological tasks push and motivate students to go beyond their ZPD by increasing the challenge level, is endorsed by Klingberg et al. (2005) and Bergman Nutley et al. (2011), and shown to contribute towards accomplishing the desired gains in EF skills.

However, although technology's role in motivating students with EFD to repeat a task is widely accepted, many teachers in S1 reported that it may not be the case every time. This is because, while technology provides a facilitative role all the time, it can sometimes inhibit learning through various means. For example, devices often present many distractions, and students may switch to non-training programmes if guided use of the device is not maintained (Neiterman and Zaza, 2019). This can be a particular problem if students have attention and concentration issues, such as ADHD, as training and repeating the same task, even on an engaging and non-monotonous device, may impact their motivation and desire to use it. This suggests that the intermittent use of other strategies between technology-based sessions are required to maintain their attention. The use of reinforcement and rewards for repetition when periods of work for a task or skill were long was also used to positive effect by the teachers in this study. This indicates that immediately rewarding performance and not delaying gratification adds to the effect of increasing students' engagement and attention duration.

5.5.7 Different classroom strategies and approaches to support EF development

The findings of this study show that no fixed solution or strategy was universally applied, but rather a mix of different strategies and approaches were executed by teachers. These involved modifications to the curriculum and the instructions from teachers, and reflected variations in students learning needs and their level of difficulties in using the technology. This is in line with previous literature that indicates that, in a special education context, varying degrees of difficulties can be addressed through a mix of strategies to direct behaviour towards academic performance. For example, Kryza (2013) and Rosenshine (2012) highlighted the importance of a mix of strategies, such as differentiated instructions and one-to-one instructions, to support students in the classroom and develop their independence, while keeping curriculum requirements in mind. However, the findings from all three cases indicate that teacher mediation and interaction to guide and develop skills was a common feature, and it was crucial for better understanding and monitored use of technology.

The sections below further explore how different strategies relate to the underpinning theoretical construct of Vygotsky's social cognitive development, and the role of scaffolding and guided participation as central aspects of developing EF skills in students when using technology. The prevailing notion in all three schools that repeated practice was the most essential factor for any strategy or approach to learning through technology to be effective is also considered in relation to the concept of the ZPD. This finding supports the view of Diamond and Lee (2011) that successful strategies for EF development entail repeated practice while progressively enhancing the challenge level, for students to reach the consequent. The discussion below also reflects on the challenges that limited teachers in implementing these strategies, due to various factors.

5.5.7.1 Teacher-student interaction (scaffolding) for technologically mediated learning for EFD improvement

Findings in the current study identify that scaffolding, along with other strategies, provided significant benefits for students with EFD. An example of this is in terms of regulating their behaviour and learning through contingent guidance and instruction from teachers, and the development of students' independence once they had learnt to carry out a task. This has also been validated through previous research which shows that EF skills can be cultivated through scaffolded practice (Bardack and Obradović, 2019; Zelazo and Carlson, 2020).

The case studies showed that three major types of strategies had been formulated across the three schools, with student-teacher interaction, specifically scaffolding, being the most common, followed by one-to-one instruction and group-based interactive sessions. Teacher-student interactions that involved scaffolding by teachers, using technology or more traditional techniques, was further aided by facilitative steps to ensure a regulatory mechanism for learning tasks. These included physical and verbal prompts, direct instructions, modelling of desired behaviour or actions, occasional instructions, asking intermittent questions, disciplinary measures if any unwanted behaviour was exhibited, and minimising distractions and off-task behaviours.

This approach to scaffolding is consistent with the steps proposed by Hammond et al. (2012), Raiser and Tabak (2014) and Echevarría et al. (2017), who deem this process effective to maintain students' direction and develop their organisational skills. Moreover, to control and regulate behaviour, teachers made use of motivation and reinforcement to keep students focused on task completion. The role of the teacher as a MKO in enabling the student to reach their ZPD was also evident in certain cases. Initially, students were engaged in technology-mediated tasks through assistance from teachers as the MKO in various functions of the application. This step, which Tharp and Gallimore (1988, p.35) call "other assisted" progresses to "self-regulated" after three to four instances of receiving assistance from the teacher, who then "fades" the support. Classroom observations showed that students were able to exhibit learning or an internalised skill by practising the task on the device without the teacher's assistance. This is in accordance with the view of Margollis (2020) that scaffolding is initially an assisted performance that enables students to reach their ZPD after certain guidance, and Van de Pol et al. (2010), who viewed the learning as proceeding through contingency, fading and the transfer of responsibility.

5.5.7.2 The role of instructional scaffolding in the effective use of technology

While previous studies have largely focused on parental scaffolding and its influence in developing EF skills in children (Hammond et al., 2012; Deater-Deckard and Bell, 2017; Shaffer and Obradovic., 2017), this study investigated the role of teachers' scaffolding in addressing EFD using both technological and traditional approaches. The importance of instructional scaffolding was specifically recognised by S2 teachers, even though they primarily incorporated it due to lack of additional staff. They were observed providing verbal instructions, modelling the task to the whole class, gaining the attention of all students at the same time, and commenting on their performance and actions. This supports the argument of Mathis and Bierman (2015) that, if these different aspects of instructional scaffolding are kept in mind, including directive and elective verbalisation on students' expected actions and performance, the cognitive capabilities of the students are improved. Classroom observation also showed that, when these teachers asked students to perform a task on an iPad/tablet, they questioned them intermittently to assess their engagement level, reasoning abilities and learning tendencies. This corroborates findings of Nelson and Johnson (2016) that teacher-directed instructions during iPad-assisted learning reduces task refusal in students with EFD and promotes the targeted behaviour.

As Bonawitz et al. (2011) note, instructional scaffolding and questioning can also develop self-exploration skills and self-regulation by involving students in discussion and enabling them to interpret the tasks, thereby enhancing CF and increasing attention. However, it was observed that, in whole-class instructional scaffolding, teachers could not reach out to each student individually, therefore, using similar instructions and scaffolding techniques was not an effective measure in a setting where students varied in their difficulties and level of learning needs. This is in line with the views and findings of Taber (2019) that one size does not fit all, as the EF construct varies from one diagnostic group to another, and what works for the EF skills of students with autism may not work for those with ADHD. This may explain why teachers were not able to involve every student while practicing instructional scaffolding, as some were not listening or paying attention to them all the time. This observation is at odds with Vygotsky's approach of co-construction of knowledge through mutual engagement and understanding in an activity, as it requires students to be actively engaged in the learning and co-construction process in order to follow instructions and benefit from the guidance of an experienced teacher (Ciullo and Dimino, 2017). Hence, employing a similar scaffolding strategy may limit the effectiveness of explicit instruction and inhibit the development of desired skills. As de Oliveira et al. (2020) indicate, teachers need to be prudent when selecting scaffolds and strategies, and take into consideration the goal of developing EF skills by using scaffolding appropriately.

According to Vygotsky's theory of cognitive development, rich social interaction through effective and timely mediational techniques upgrades fundamental cognitive capacities to more advanced and complex cognitive functions. Relevant to this is the role and presence of the teacher as MKO, and their personalised exchanges require significant attendance and presence of the teacher for each student. However, it was apparent in the observations that a single teacher providing instructions and observing the entire class at one time could not address the questions and problems of each student fully enough to allow them to develop the skills required to learn the task. The time during which the teacher addressed and instructed the students was an interactive learning phase; however, after that, some students' attention waned, possibly because they were still not ready to complete the task independently.

For a technique to operate effectively in developing EF skills, optimal social interaction must be facilitated until students master the skills, and then the teacher can fade the support and become more of an encourager than an instructor (Amado et al., 2016; Anguera et al., 2020). Nancy (2017) further relates that the teacher's facilitation throughout the learning process is the primary contributor to cognitive skills development, and that asking and guiding students intermittently and then monitoring progress requires them attending to students closely. Thus there is constant need for cognitive, social and emotional exchange between participants in the instructional process. However, due to the lack of support staff and additional teachers in the classroom, the social interaction between the teachers and students was not consistent, and the findings illustrate deficiencies in the teacher-student interactions needed to develop consistent guided participation. Establishing such interaction would enable students to internalise the required guidance from teachers and to progress to the desired level of proximal development more easily.

Scaffolding involves the execution of different strategies by a competent teacher in line with the cognitive profile of students. Teachers take responsibility for students' learning by helping them to focus, breaking down work into easier steps based on their current level of competency, maintaining their motivation on the task, and eliminating any unwanted behaviour during learning. The findings illustrate that direct scaffolding of students through teacher mediation until the time they can accomplish tasks independently was seen as important in optimising their self-regulation and independence. However, due to the teachers' inability to reach out to all students to offer contingent help, the gains made could not be assessed for their permanency. This illustrates that the effectiveness of scaffolding in a context where students having various difficulties, requires individualised instructions and interaction, as well as adequate teacher expertise to address those difficulties.

The above findings are consistent with Wilson and Devereus' (2014) view that, to develop cognitive skills for students with cognitive challenges, teachers must train them through challenging and supportive instruction. To complete this stage of learning, teachers must maintain a balance between approaches, that is, the curriculum, instructions, and materials, as well as their own expertise. In addition, the findings of Athanases and de Oliveira (2014) are particularly appropriate in the context of this study, as they showed that instructional scaffolding cannot be effective, despite teachers' effort and high levels of support, unless they have knowledge and competency relevant to the students' difficulties. Without this, they cannot help them reach their ZPD.

The findings also reveal that teachers faced difficulties in managing students in a collaborative or whole-class learning session. For example, the teachers in S3 identified a need for additional staff assistance to keep students on track, as they could not be left alone with devices for practice, owing to their unpredictable and unregulated behaviour. This finding further relates to the argument of Bardack and Obradovic (2019) that teachers face challenges in maintaining control, attention and behaviour when their skill level is not appropriate for a given context or the level of difficulty students experience. As was observed, with a general lack of experience and knowledge of using technology with EFD, most teachers were executing open-ended teaching strategies without any standard determination particular to addressing EFD.

Due to this limitation in their expertise, teachers also encountered challenges in different aspects of instruction and teaching, such as in planning individual or collective tasks, executing strategies, and assessing gains and students' performance. Moreover, they reported that reaching out to meet diverse student needs was a challenging and time-consuming task. This is consistent with the observation of Ertmer and Simons (2005) that teachers lacking context-specific experience in using the right instructions and strategies report challenges and difficulty in implementing strategies and controlling students through different transitions between tasks. Hence, they struggle to achieve effective learning in students. This relates to the importance of the MKO, according to Vygotsky's concept of scaffolding and cognitive development as, if they are not competent to address the students' difficulties and recognise their ZPD, the effectiveness of the intervention/strategy is also undermined.

5.5.7.3 Using multiple context-specific strategies to support students with EFD

In addition to using the scaffolding approach to facilitate learning through teacher-student interaction, the findings illustrate that teachers incorporated other ways to facilitate learning and ameliorate cognitive difficulties in students. Multiple context-specific strategies were observed being executed by teachers, for example, to develop skills such as planning and organisation, WM, IC and CF in the students, with the instructions, practice opportunities, and feedback designed according to the skill that was being targeted. These included both classroom accommodations (classroom schedules, planners, checklists) and different technological features (e.g. digital reminders) to help students regulate their EFD. However, observations indicated that improvements in EF were more obvious with digital accommodations and practice than with traditional tools. For example, students had to be prompted to follow calendars or schedules that were displayed at different points in the class, however, with digital tools, these appeared on their screen intermittently, so students were reminded about their schedules without the need for any external prompts. This indicates that visual representations using technology required less enforcement than explicit systematic instructions for students with EFD to show effective gains.

The findings also illustrate that students were encouraged when teachers provided scaffolding for their particular difficulties: for example, modelling for them how to organise their work in light of their organisational difficulties, and then enabling them to practice by providing effective instructions and giving them complimentary feedback immediately to reinforce their learning. This also improved their self-regulation and self-discipline. Likewise, guiding them to memorise phonics through a device/application, enabling them to practice a sum on an application, and then encouraging them by complimenting them, improved their WM. In doing this, teachers made use of several different strategies to improve students' self-control and impulsiveness, and then reinforcement (rewarding desired behaviour) served as a means of retaining their focus on practising for the required time. These findings align with the processes and features of explicit and systematic instructions that teachers endorse in their scaffolding practice, as mentioned by Smith et al. (2016), who state that teachers should incorporate methods that facilitate the learning process in such a way that gains are observable in a sequential manner using skill-building activities.

Using different strategies in different contexts further relates to addressing different difficulties for different students. This practice was prevalent in all three schools, where teachers were applying different techniques to address different cognitive difficulties faced by students, and drawing on technology's potential to ameliorate multiple difficulties. The modalities of different approaches were perceived to address the different challenges of these students, and their synergetic effects were seen as improving cognition and other EFs. This phenomenon has been acknowledged by previous studies of the combined effect of cognitive tasks. For instance, de Oliveira (2019) and

Benzing et al. (2019) found that a combination of classroom-based interventions and different instructional strategies targeting various domains of EFD, produces a greater impact through multimodal training rather than adopting a single approach that may not produce broader transfer effects in these students.

In addition to this, several strategies that were simple to execute were applied. For example, digital tools like reminders, calendars, schedules and visual checklists were used to reinforce memory, planning, organising and self-regulation skills and help students self-regulate their tasks. This strategy's effectiveness has been recognised by previous studies; for example, Greenstone (2011) reports that the ease of applicability of strategies involving digital calendars, organisers and memory aids makes them efficient to use, and their advantages can be generalised to other contexts. They also serve as reinforcement for practice in a different context. Doabler et al. (2012) also found that such easy and applicable strategies can have long-term gains and can be generalised to various contexts for students.

Diamond and Lee (2011, p.959) indicate that a range of activities, including "computerized training, noncomputerized games, aerobics, martial arts, yoga, [and] mindfulness", can enhance EF in children. However, the findings of the present study do not identify any standard interventions or activities that are specific to the improvement of EFD. For instance, the effectiveness of curriculum modifications implemented to help struggling students was not known. This relates to teachers' lack of knowledge of about EFD and the limitations this placed on their ability to select and use technology practices based on students' actual learning needs.

5.5.7.4 One-to-one instruction as a potential strategy to address EFD

The findings of the present study illustrate that one-to-one instruction is one of the most effective potential strategies to address EFD while using technology. However, as students with EFD require additional effort, monitoring, and time from teachers when using technology; accomplishing this in a context of diverse students was not possible all the time, as it was not practical for teachers when managing several students at a time. For example, as mentioned above, teachers were observed to be 'struggling with monitoring' every student, meaning some students exhibited impatience while waiting for assistance with devices, which affected their progress in learning. This further emphasises the need for additional staff in the classroom, where one teacher should be appointed for delivering instruction and others should monitor the students' progress and performance.

The student-teacher interaction through one-to-one tutoring in technology-mediated learning has been found to be effective in developing skills, as needs are identified early. Also, this type of interaction is believed to improve academic skills more readily, with broader transfer effects (Hickey and Flynn, 2018). Previous literature has also identified this method as an effective means of controlling and managing student self-regulation and directing their learning behaviour. This implies that teacher-student interaction, with contingent support, coupled with technology, is an effective combination (Bardack and Obradovic, 2018). It could also help to overcome challenges faced by students when performing a task. Classroom observations in this study showed that student-teacher interaction was also effective in providing students with appropriate directions until they could complete tasks independently using devices. Practically however, achieving this sort of interaction is a complex task in the absence of additional staff and resources, especially when class sizes are large.

The findings discussed in 5.5.7 and its sub-sections have particularly reflected the importance of the use of multiple strategies using technology in managing EFD in students. The findings have established that scaffolding using explicit and systematic instructions is an effective means of enabling students with EFD to progress, using both traditional instruction and technological measures as cognitive and learning tools to develop their cognitive capacities. However, multiple challenges were also identified in developing the scaffolding practice effectively, including a lack of the individualised attention and instruction required by students with EFD. This is compounded by a lack of additional staff to monitor students and assist teachers, inadequate numbers of devices to allow each student to practice individually, and most importantly, teachers' lack of competency pertinent to developing EF skills.

It would, therefore, be unrealistic to assume that the incorporation of technological tools automatically reduces EFD in students. Rather, identifying and using the appropriate affordances and functions of technology to handle EFD requires deliberate attention and guidance from teachers. In addition to teacher-related factors, various contextual factors also influence the impact of technology, such as the compatibility of instructional tools with cultural factors that determine students' engagement. A relevant example in this regard is the limited availability of Arabic versions of applications, a major concern for all three schools. The design of instructions and task configuration using technology, coupled with how tasks are staged, whether through scaffolding, one-to-one instruction, multiple strategies or group interactive sessions and delivery, can influence students' cognitive ability to perform initial tasks. This is important, as students with EFD are particularly vulnerable to cognitive overload during learning and face challenges in managing their processing efforts during instructional activities.

Overall, the findings indicate that, in order to act as an effective MKO, teachers should adopt the best approach for the needs of their students. This includes the use of appropriate instructions (explicit and systematic), providing adequate scaffolding, and selecting strategies for the use of technology which are age-appropriate and recognise students' individual developmental levels. This requires the provision of adequate support, including specialist training, classroom assistance, and the availability of sufficient devices to meet demand. However, the generalisability of these findings cannot be established, as the parental role in practising these strategies was minimal or not known.

The next section expands on the positive contributions of technology in the overall learning of students with EFD as perceived by teachers and parents, and reflects on these findings in the light of previous studies.

5.6 **Research Question 3: *What are the main contributions technology is making to the learning of students with EFD?***

5.6.1 Positive contribution of technology in developing EF skills

Research Question 3 focused on participants' views on the positive contributions of technology in developing EF skills. The major theme that emerged under was an improvement in academic readiness and in a range of different skills, including reading, writing, numeracy, and learning skills with the use of technology. However, the findings also reflect challenges and limitations to using technology effectively with students with EFD.

5.6.2 Technological affordances and improvement in EF skills

Previous studies indicate that technology-mediated learning holds the potential for academic improvement by enhancing EF skills (Nyroos et al., 2018), with improvements identified in reading, writing, mathematics and general learning skills (Rapoport et al, 2016). In support of this, the findings of this study indicate that the ability of technology to mediate, engage and redirect students' disruptive behaviour towards learning makes it an efficient instructional tool for students who are cognitively impaired and who find it difficult to remain on task for long.

The ability to make learning practices innovative, by supporting and enabling instruction delivery in a way that facilitates engagement and motivation for learning linked to academic subjects by regulating students' independence is fundamental in academic progress. Relative to participation in traditional instruction, the findings of the present study illustrate that students were better able to complete and learn tasks in iPad-mediated activities and that their performance was maintained beyond the classroom, as reported by parents when they practised the task on the same application at home.

Based on the data collected from this study, other features that make technology a contributing tool in improving overall EF skills are ease of portability, the direct interface that makes control and use easy for both teachers and students, and the multi-sensory nature of the audio-visual platform, which engages and retains students' attention. These enable students to self-regulate and experience independence that they could not feel in a collective atmosphere of traditional learning. Moreover, adaptive design makes it easy for the students to learn according to their difficulty levels, thereby providing a more personal approach for students with EFD. Indeed, the findings suggest that students with EFD prefer technology for the ease of learning it allows relative to the cognitive demands of traditional learning approaches. This view is endorsed by Beal and Rosenblym (2018) in that technologies afford ease of compatibility with students' learning capacity through modification of features and visual interactive instructions, making it easier for students to prolong their attention period relative to teacher-based methods.

The findings also indicate a positive disposition of teachers towards technological affordances, despite the many challenges and concerns they face in using them effectively. In this context, the findings show that there are easy-to-use tools and features of technology that do not call for complex designs and configurations, and which can address multiple EFDs, along with other social and communicative demands placed on students. For example, different features on personal iPads and tablets were identified as an effective means of training students in organising, planning, scheduling and managing their time for different tasks, activities and materials. Using a simple timer tool on these devices can enable the student to visualise the time required for a task and thereby enable them to regulate themselves to complete the task within that time.

Similarly, the interactive visual checklist offers a simple but effective way to promote self-organisation, as students were more engaged in following the to-do list highlighted on the device feature. The graphic organiser tool also offers the affordance of connecting different sequences of tasks and different parts of a single task to help these students remain on track. These affordances have been acknowledged by previous studies. For example, Kellems et al. (2016) report that these features help students in developing EF skills and improving their academic performance, and that part of the attraction these devices hold for students relates to improving their skill levels both at school and home. The happiness students in the present study showed when they reached the next level in device-based activities indicates that this may also be the case across the range of diagnostic groups represented here.

5.6.3 Pedagogical affordances of technology to improve reading, writing and numeracy skills

Academic functions and learning in a classroom context require EFs that are appropriate for the learner’s age and their academic development (Coyne and

Rood, 2011). The findings demonstrate how impairment in multiple aspects of EF limits the student's ability to show efficient academic progress. Students with autism, ADHD or dyslexia demonstrate challenges in memorising information, and planning and organising their learning schedules in a meaningful way, limiting them in terms of developing proficient reading, writing and numeracy skills. This is further considered to be related to common underlying features, such as inattention and inability to memorise information due to weak WM.

The steps, sequences and structure of the technology-based activities and tasks provided to the students in this study enabled enhanced regulation of the thought processes and associated actions that direct their attention, inhibit switching behaviour, and develop their critical thinking. Findings in this context also demonstrate that the practice of tasks and activities using device-based rehearsal produced improved EF skills and resulted in stronger academic performance. This is in line with previous studies which have shown that repetitive practice of EF-based academic tasks and activities are key to EF enhancement, and that using technology-based learning keeps students engaged, prevents them getting distracted and helps them retain and follow given instructions, which in turn leads enhances academic performance (Schmitt et al., 2017). However, further research is required to provide deeper insights into how the tailoring of mechanisms involved in improving academic skills are determined and how the contribution of technology to the overall learning improvement of students with EFD is attained.

The findings from the present study do, however, support the view that technology is helpful in directing students' behaviour towards learning and academic improvement in various learning skills, such as in reading, writing and mathematics. Teachers supported the view that technology holds the potential to clearly direct learning-related behaviour that benefits academic progress in these students in a way that could not be accomplished with explicit instructions alone. For example, students' difficulties focusing their attention on a task, or following classroom rules or the teacher's guidelines, were addressed by using technology as a motivator or reinforcer, or showing students videos that strengthened their intention to follow these guidelines. This can be considered technology's primary pedagogical affordance in developing the preferential habits of these students. This correlates with the view of Manta et al. (2020) that using technology to strengthen the habit of completing an academic task is making use of its affordances to develop students' preferences towards learning. For example, in the present study, this was achieved by using a device to reinforce a student's intention to complete a task immediately after a break. This desired behaviour is initiated without overtly pushing students, with prompts used to motivate them to initiate and complete the task. Hence, reflecting the power of devices to direct students' attention and behaviour towards learning, leading to improvement in both EF skills and academic tasks. This is in line with evidence from earlier studies that both learning-related behaviour and EF skills are each mediated by using technology in the classroom, as technology provides a medium for integration and coordination of the skills required to improve academic performance.

The findings also demonstrate that using application-based practice of mathematics problems helped improve the foundation skills that are needed to acquire numeracy skills. Different applications on the iPad, such as subtraction and addition games, were found to improve students' numeracy skills, through tasks that these students had been unable or unwilling to perform when they were presented through traditional methods. This relates to the power of devices to engage students for a sufficient length of time to enable them to memorise the required steps by retaining their attention and controlling their impulse to move to another page or task (IC) and also by alleviating the cognitive load through integration of auditory and visual content leading to learning gains.

This is in line with evidence from previous studies that have reported significant improvement in WM, IC and task-shifting through the use of technology, thereby enhancing numeracy skills (Gomez et al., 2018; Cragg et al., 2017). Similar views are mentioned by Goldin et al. (2014), in that application-based mathematical practice helps develop EF foundation skills, such as WM, which help students develop their capacity to remember, organise, prioritise and shift - skills that are crucial for solving numeracy skills. However, effective teaching strategies have also been shown to play an equal part in this development (Agharuwhe and Nikechi, 2009).

In addition to using technology functions for academic benefits, teachers also mention that technology eases the path to accessing the curriculum for EFD students, as they otherwise have difficulty setting goals and remembering schedules. For example, when students with autism in S3 experienced difficulty in tasks requiring planning, shifting attention, iPad-assisted activity was reported to regulate these issues for the students. Teachers also reported that using visual strategies with digital features enabled students to effectively plan, manage time and shift between different steps of a task performed on a device, meaning that they accessed the curriculum content more efficiently.

In addition to this, from the parental perspective, three main potential pedagogical affordances were identified that contributed to academic skills development among students with EFD. Parents were found to believe that technology cultivates the potential for their children to access learning resources which they were otherwise reluctant to access, utilising digital features to explore their internalised learning tendencies, and that the support these devices provide through audio-video features helps to improve their literacy skills. Furthermore, the collaboration enabled by devices allowed parents to participate with their child at home, acting as an MKO to help them practice tasks through games or other inbuilt features, thereby enhancing their child's academic learning development.

Technology was frequently incorporated in the case study classrooms to attract attention, motivate students, and facilitate instructions. The apparent disposition of teachers to use technology across all schools was linked to seeking to improve instructional quality using technology as a mediator, and this was shown to be effective in individual cases. However, the findings also demonstrate that technology's role in improving academic learning could not be determined easily due to the varying learning needs and difficulty levels of students, and the view that relying extensively on technology was not always a positive experience for these students was also expressed. Hence the overall pedagogical affordance and role of technology in assisting learning of students with EFD could not be clearly ascertained.

A lack of generic applications that could facilitate EF development specifically was also apparent. However, the limited Arabic applications available were used to improve basic reading, writing, and numeracy skills through repetitive tasks. Despite revealing a positive attitude towards using technology to facilitate academic skills among parents and students, the findings did not demonstrate whether students were able to perform tasks in other contexts or through non-technological media if the opportunity was provided. Moreover, there was a lack of relevant applications and software through which to practice more complex functions to develop the cognitive abilities of the students more efficiently. Teachers also had difficulty coping with students due to the absence of EF-based learning designs for these students.

Relative to this apparent disposition of teachers and parents to accommodate technology, there were also some concerns about its use in the academic context. For instance, students with cognitive difficulties are not always able to understand the demands that the digital interface can place on them, and their use requires guided practice from an MKO. This is in line with the view of Nijboer et al. (2013) that using technology in this way requires mature guidance to choose a cognitively efficient means of doing and completing tasks and productive learning activities. Moreover, the findings do not take into consideration the teachers' and parents' views about the social implications that may develop with excessive use of technologies, such as social isolation and students becoming more dependent on technology to support their cognitive wellbeing (Kinsella et al., 2017).

These findings are also associated with teachers' limited knowledge regarding the actual use of the pedagogical affordances of technologies towards improvements in EFD. There are a multitude of potential uses for technology to accommodate academic practices. However, for teachers to effectively integrate technologies into their learning designs for students with EFD and to utilise them effectively in the classroom, they need to develop their knowledge and understand the affordances these technologies can provide in their academic contexts.

The following section discusses challenges and limitations specific to addressing EFD as identified in the context of different schools in KSA.

5.6.4 Challenges and limitations in the potential use of technology

Despite the proliferation of efforts to facilitate better technological solutions and increasing reforms in the educational setting in Saudi Arabia, the findings of this study have identified training and support challenges as major limitations that may impede teachers' effectiveness in the integration and use of technological solutions and their role in EF skills development.

5.6.4.1 Insufficient training and support facilities to improve EFD in students

The significance of teacher effectiveness in using technology appropriately further relates to the question of addressing multiple learning challenges in students and their role as MKOs. Teacher effectiveness is dependent on the appropriate and adequate provision of training and development (AlFaraj and Kuyini, 2014) and is linked to the extent of teachers' use, integration and attitudes towards using technology. Teachers' effectiveness, knowledge level and competencies also relate to their decisions regarding technology selection and use in a given context. AlFaraj and Kuyini (2014) further identify gaps in knowledge regarding technology use in Saudi special education teachers, and this study also found that adequate and context-specific formal training was missing in all three schools studied.

Training can increase the potential for determining the right pedagogy, strategies and tools to enhance teacher preparation and develop their actual ability to help students with different levels of difficulties. Moreover, it enables teachers to overcome the obstacles faced in the execution of technology-based lessons. While all of the participant teachers had considerable teaching experience related to students with cognitive difficulties and to using technology, their technical knowledge and skills were not up to date; this indicates a strong need for further training and professional development in all three schools, regardless of the teachers' previous academic and working experience with students with learning difficulties. In addition, owing to the availability of high-technology devices in all of the schools, there is a requirement for specialist training due to the complex features of such devices, as proposed by Adebisi et al. (2015).

These findings run contrary to the view of Flanagen et al. (2013) that teachers who have extensive teaching experience develop the necessary expertise and skills in using technological tools in the course of their work. Relative to this, Alkahtani (2013) points out that teaching experience may not have involved the appropriate use of technology: hence, teaching experience cannot be equated with use and knowledge of technology, and that professional training in this area is required. The findings also indicate that a preference for using technology was inhibited by the use of traditional approaches in some teachers in S1, and that this may relate to a lack of training facilities, as well as the teachers' lack of efficacy in selecting and using devices.

Okolo and Diedrich (2014) mention that these variables, namely, the selection and adoption of technology, are significantly linked to teachers' training, which is therefore crucial for the effective use and integration of technology. Moreover, the increasing trend for an inclusive educational framework in the Saudi Arabian context calls for additional training and development of teachers to address the unique learning needs of students with multiple difficulties. However, the findings here demonstrate that gaps in provision are still prevalent, particularly in content-specific training provision, as highlighted in interviews with teachers. This also implies that technology has been implemented in teaching plans without adequate training provision. Thus, teachers' preparedness for using technology with students is inadequate and may impede their ability to exploit technological affordances fully, having not been trained on all of the features and content of a device. This issue was referred to by Krauskopf et al. (2012), more than twenty years ago, and steps should now be taken in Saudi Arabia to ensure it is addressed well before the Vision 2030 reforms are concluded.

5.7 Conclusion

This chapter has explored the study findings obtained from interviews with teachers and parents and from classroom observation in light of the literature reviewed in Chapter 2. The main argument put forward in this chapter is that the use of technology to address EFD in students in Saudi schools is hampered by a lack of adequate knowledge about using technologies with these students, which further relates to the teachers' lack of awareness and knowledge about EF, EFD, and interventions that are specifically formulated to address these challenges. Furthermore, the effective use of technology is limited by the various challenges and limitations that exist in all three schools due to insufficient facilities and support. In these contexts, the major barriers to the successful integration of technology are the lack of appropriate and field-specific training and development opportunities for teachers, the lack of technical support and additional teaching assistance in the mainstream inclusive setting, and access to technological resources to facilitate the individual learning needs of students.

The research also indicates the need for all schools to consider developing and deploying EFD-specific approaches, interventions, and technological tools to experience actual changes in understanding of EFD by teachers. Improvement in the efficiency of these elements relates to the development of optimal and repeated practice opportunities for these students, which is a key factor in the development of EF skills using technology. In addition, these improvements should further relate activities to the developmental age and learning stage of each student, enhancing the complexity of tasks and challenges as appropriate to enable growth in the skills learned. It is also important to cultivate opportunities to address EF development for different ages and characteristics of students, and this requires the development of interventions that are versatile and flexible, not only to develop and improve EF skills, but also to enable transfer of learning to a different context. The findings of this study therefore have significant implications for authorities designing and devising teachers' professional development and for curriculum design bodies', notably in relation to addressing gaps in awareness about EFD in the mainstream setting and developing the competencies of teachers to address these challenges, in order to improve contemporary policies being designed for students with cognitive difficulties in Saudi Arabia.

The following chapter draws conclusions from the findings and discussion and considers the implications for practice, making recommendations for teachers and policy makers to enhance the use of technology in Saudi classrooms to support students with EFD.

6 Chapter 6: Conclusions and Contributions

6.1 Meeting the aims and objectives of the study

This study has examined the use of technology in Saudi primary schools to support students with EFD, from the perspectives of teachers and parents. Data was gathered in three different schools, and the support offered to three diagnostic groups (students with autism, ADHD, or dyslexia) was targeted for investigation. The underlying aims were:

- to assess the use of technology in a mainstream setting, among different diagnostic groups of students in order to assess the variation of EFD in each group;
- to understand teachers' and parents' perspectives, with regard to their awareness of EFD and how they believe technology could help to address the complex difficulties associated with it;
- to examine the actual strategies and techniques Saudi teachers use to incorporate technology into their classrooms and identify how these could be improved to enhance students' learning;
- to inform and advise educational professionals, school authorities, and educational policy- and decision-makers, and researchers in this field.

In order to achieve these aims, the study sought to answer the following research questions:

1. To what extent are parents and teachers aware of the concept of 'executive function difficulties (EFD)' in Saudi schools?

2. How is technology being used to support students with EFD in Saudi schools?

3. What are the main contributions that parents and teachers see technology making to the learning of students with EFD?

The conclusions which can be drawn from this study in respect of these aims and research questions and the contribution to knowledge they represent are set out below.

This study makes a significant contribution to knowledge in respect of the use of technology to address EFD in young children, especially in the Saudi context, where little research on this topic exists. Indeed, to the best of the researcher's knowledge, this research represents the first systematic investigation into how EFD, coexisting in three different diagnostic groups, influences students' academic capacities in complex ways, and how these might be addressed in the classroom using technology. The study is also novel in that it targets EFD in different groups of students in one of the fundamental contexts of analysis, that is, schools. Previous studies have typically focused on home settings rather than schools, so the present research represents a first step toward addressing this gap in the Saudi context. The focus on the use of technology in inclusive mainstream schools is also significant for a number of reasons, firstly, because inclusive education is now being promoted by educational authorities in KSA, secondly, because such settings provide a more general and varied environment than that offered by special schools, and thirdly because it enables the research to identify the challenges teachers and parents can encounter in seeking to support students with EFD in mainstream classrooms, the affordances technology can provide, and the issues associated with its use in this context.

6.1.1 Assessing the variation of EFD in each diagnostic group

The present study is distinctive in that it has considered differences in EFD in three diagnostic groups, namely students with autism, ADHD, and dyslexia. While classroom settings may appear to present more cognitive challenges than children face at home, due to the focus on formal learning, the views obtained from parents and teachers recorded similar difficulties in both school and home settings within all three diagnostic groups. As a result, a shared set of features were identified in students with autism and ADHD, namely: a lack of attention and consequent difficulty in remembering, staying focused on a task for long time, and switching from one task to another. For students with dyslexia, behavioural challenges were not as significant as those reported for other students; however different technological capabilities were found to regulate their memory and help them to learn to read and listen to the text, thereby increasing their motivation to practice these exercises using devices.

The findings from the three cases indicate that technology offers both an effective tool to address the cognitive complexities associated with EFD and a way to motivate, facilitate, and reinforce students' learning, and stimulate behaviour which enhances the development of their academic skills. It can also be used as an effective way to gain students' attention, to engage and entertain them, and to provide a break from regular instructional sessions. These aspects are particularly significant for students with ADHD, autism and dyslexia, as they typically struggle with WM, CF, and IC as a result of their EFD. The fundamental affordances of technology identified across all three cases were self-regulation, organisation, management and planning skills. These were largely provided through assistive built-in features (e.g. visual schedules, calendars, timers, note-taking features, photos, audio notes, and reminders), and a limited number of specialist applications. The findings therefore demonstrate technology's potential to improve the underlying difficulties of attention, focus, engagement and self-regulation skills which occur in all three diagnostic groups.

The study further enabled assessment of how these technological tools and features encourage self-regulation through better planning, organisation and time management skills. The findings suggest that technology-mediated learning can enable students to memorise more easily, stay focused, control their inhibitions and avoid unnecessary switching from task to task, by comparison with traditional ways of addressing EFD. It also assessed whether enhancing students' cognitive functions improved their academic abilities and influenced their motivation towards conventional learning in general reading, writing and numerical tasks. Confirmation of the positive role of technology was evident in all three cases and across all diagnostic groups. The findings for the three cases also illustrate that the use of technological tools in the classroom encourages cognitive engagement for students with EFD; this aspect can help to overcome their problems with flexibility, regulating their own behaviour, and goal-directed behaviour, all of which are significant to succeed academically, as well as later in their professional lives.

However, despite this consensus, results obtained from different participants indicates that technological tools require customisation from student to student, and that a "one size fits all" approach is not appropriate. The teachers in all three case studies believed that what worked with one group of students may not be as effective with others, due to variations in students' behaviour and their cognitive complexity. Students' various needs and levels of difficulty should therefore be considered when choosing interventions to address EFD. The present study is novel in highlighting the need to develop diagnostic standards for EFD in different diagnostic groups to identify the differences between them and then determine the most appropriate strategies on a case by case basis, depending on the specific learning needs. It also clearly demonstrates that the realisation of technology's full potential depends on teachers' knowledge and capacity to use both traditional methods and technological tools, and their ability to understand the particular difficulties students exhibit, both conceptually and contextually.

6.1.2 Teachers' and parents' awareness of EFD

As noted above, to the best of the researcher's knowledge, this is the first study to explore the concept of EFD in Saudi schools, and a notable finding relates to the lack of awareness of the construct and its complexity among the participants. Neither teachers nor parents were familiar with the term "executive function difficulties (EFD)", and they did not know about EFD as a separate cognitive difficulty; however, they did perceive that the difficulties shown by students in the different neurodevelopmental groups may be manifestations of EFD. This knowledge is fundamental in developing the understanding, awareness, and skills required to execute technology-mediated strategies effectively, and the findings indicate that specialist training for teachers should be provided as a priority. Once they are sufficiently competent to recognise the significance of the complex underlying processes of EF, they should be able to utilise and prioritise effective technological solutions to address EFD and, consequently, enhance the overall learning of these students. This would also facilitate greater consideration of influential factors in the teaching context, namely, classroom layout and design, to ensure that interventions and strategies to address EFD can be accommodated without exacerbating existing difficulties.

Greater awareness of EFD as a concept among parents would help them understand the origins of their child's difficulties, the specific EF skills affected, and how these might be enhanced through the use of technology. Despite the importance ascribed to parents' role in developing children's cognitive abilities (Đurišić and Bunijevac, 2017), teachers in this study reported a lack of knowledge about the difficulties their children face among parents, and limited engagement and cooperation in identifying appropriate interventions and in practising tasks at home. Better knowledge and awareness of EFD and its complexity would enable parents to understand their children's needs better, to identify more positive ways to engage them in learning, both at home and in school, and encourage greater collaboration with teachers to select and implement technological solutions to enhance their children's cognitive skills. This could be achieved by providing appropriate information and guidance for parents and encouraging them to engage with teachers to discuss their children's learning needs and the options available to support them.

6.1.3 Strategies and techniques Saudi teachers currently use

The study found that participant teachers did not have specific interventions or strategies to address EFD; instead they were addressed in the same way as general LD, through explicit instructions, scaffolding, prompting, questioning, modelling, and the use of technology as a mediator to engage and focus these students. Scaffolding was the most widely-practised strategy, and it was found to be effective when teachers were able to constantly support students in this way. However, the findings indicate that its effectiveness was often compromised due to lack of support staff in classrooms. Students with EFD, such as autism, dyslexia and ADHD, require considerable attention and, in most cases, personalised support. Hence, if these students are placed in a regular classroom without any additional support for the class teacher, it is unclear how much they will improve.

Nevertheless, teachers were found to be using the fundamental affordances of technology to help alleviate and manage EFD in the different diagnostic groups, and it was particularly effective in promoting positive attitudes to learning among students with EFD, stimulating their reading, writing and maths skills. This suggests that many technological tools can be valuable, even if their capabilities are weak with regard to pedagogical and instructional affordances.

However, many obstacles were found to impede the most effective use of technology-based interventions to support students with autism, ADHD and dyslexia in inclusive mainstream school settings. The observations indicated students with EFD were not receiving adequate attention and support in terms of teacher guidance, and access to appropriate devices and technological tools was limited. Providing specialist training would help teachers to identify the most suitable interventions and tools to meet students' needs, and the level of guidance required; however, these must be adequately resourced. In all three cases, the study found that many teachers had to use their own personal devices, with students bringing their own tablets/iPads from home. This circumstance inhibited the optimal use of technology. In addition, while features such as timers and graphic organisers were found to help students remember their essential tasks, there are few applications available in Arabic which students could use to practice and rehearse basic skills related to EFD. However, games and videos in group-based or collaborative peer learning settings were found to improve students' skills in collaborating with their general education class peers.

6.1.4 Enhancing the use of technological tools in the classroom

The findings suggest that technology has been influential in three areas, notably when it is integrated with other approaches used by teachers. The first of these is *interactivity* with content (multiple means of representation on iPads/tablets/projectors, for example, games/ videos, other learning media). The second is *engagement* with content (for example, games that involved students in performing specific action). The third is *knowledge transfer* and *memory*, as exhibited by students' responses in a joint session with other students and improvements mentioned by parents. The findings establish that technology serves to address EFD on different fronts, but knowing what works best and what is most effective varies for each student and each setting.

Overall, all three cases reflect a considerable gap in the proper use of technology to regulate EFD-specific difficulties, attributable to a lack of EFD awareness and knowledge and a lack of resources. The current study's findings have identified that the participant teachers knew the importance of technology for EF development; however, they were not able to transform its technical affordances into educational affordances, thereby enabling students to organise their thoughts and regulate their behaviour. For teachers to use technology to its full potential, they need to understand the technical affordances these tools can provide, and the most appropriate learning activities relative to the developmental age of the students using them. Enhancing teachers' understanding of technology's functions and features, along with content-specific knowledge of EFD, is therefore essential. However, there is also a need to develop new technology-enhanced activities and teaching tools, and curricula and environments, that reflect the developmental needs of the students and the levels of difficulty they can manage.

Moreover, various limitations in all three cases have further impeded the effective use of technology. These included a lack of appropriate and field-specific training and development for teachers, a lack of access to appropriate technological resources to facilitate learning, and a lack of technical support and additional teacher assistance. To manage these students' complex learning and cognitive needs, teachers need to have access to a variety of support and learning tools, and to be confident in their use, both in terms of the technical function of the technology and the various affordances they offer. Technology specialists and educational technology coaches can help teachers better understand and accommodate the available technological solutions to resolve EFD. However, there is also a clear need for schools to examine the development and deployment of EFD-specific approaches, interventions, and technological tools within their local contexts in order to achieve meaningful change in the way teachers use them. Key requirements include the development of optimal and repeated opportunities for students to practice their EF skills, as these are foundational skills for developing further academic competence. It is also important to cultivate opportunities for staff to experience EF development at different ages and student characteristics, thereby enabling them to match activities, learning content and techniques to students' developmental age and learning stage, and to increase the complexity of tasks and challenges as students progress. This demands the interventions that are versatile and adaptable in different contexts, both in terms of the EF skills they target and the learning strategies they incorporate.

6.2 Implications of the research findings and recommendations

The shift in educational dynamics in the Saudi context, that is, the movement away from more traditional to more technological and more inclusive learning, provided the driving motivation for this research. Although the authorities repeatedly stress the importance of technological integration (notably through Vision 2030), the main conclusion to emerge from this study is that the use of technology to regulate EFD in Saudi schools is constrained by a lack of adequate knowledge about using technologies with these students and limited provision in terms of staffing and resources. This issue further relates to teachers' and parents' lack of knowledge and awareness about EFD in general and the limited number of interventions formulated explicitly for these challenges.

This research study therefore makes a central contribution to knowledge and society in the Saudi context, simply by raising awareness of EFD in Saudi classrooms. However, by examining the use of technology to support EFD and identifying the key determinants of its effectiveness (challenges, limitations, resource access, teachers' knowledge), it could also serve as a roadmap for educational authorities, policymakers, researchers, and both general and special education teachers in Saudi Arabia.

The present research therefore offers a platform for practitioners and school authorities to pursue developmental programmes that can enable and enhance their use of technology to support students with EFD. The implications for teachers, policymakers, and for practice are presented below, with a focus on developing teachers professionally by involving them in the decision-making process. Recommendations to enhance current practice are also made. This research can thus be used as a foundational criterion in the field of EFD to identify and assess gaps in provision and provide the institutional support necessary to implement context-specific solutions and other accommodations.

6.2.1 Implications for teachers

It is apparent from the findings that participating teachers and parents were concerned about harnessing the power of EF to facilitate the learning, development, and academic well-being of students with EFD.. Given the diversity and versatility of executive functioning, teachers and parents should understand that improvement depends on contextual and conceptual specificity, or knowing what relevant concepts mean and entail, as well as what works best in a specific setting. Hence, teacher-oriented practices that promote the use of meaningful, EF-specific, educational strategies and then effective collaboration with parents to practice those at home, will improve technological and pedagogical interventions for EFD. There is also a need to promote collaboration between general and special education teachers to enhance co-teaching practice and facilitate better planning for students' regulation of EFD.

The findings indicate that, in order to realise the full potential and affordances of technologies specific to EFD, teachers need to learn about contextual use of technology, followed by sequential practice through specific programmes and applications. Teachers are more likely to execute better technologically facilitated activities for students with EFD if they understand the technologies involved. However, developing a holistic understanding of how to use and implement a tool, its technical affordances, and its educational efficacy, is not an automatic process. All teachers in inclusive mainstream education, whether general or special, should not only learn how to teach using technological tools to address EFD (e.g. teaching them how to use the device or application and demonstrating its functions by way of various examples), but should also be informed about the tools themselves (i.e. their technical and educational affordances). Providers of such training should include experts in the field of technology as well as in education. Moreover, considering the versatility and variance of the EFD constructs and different learning profiles of each student, there is a great deal of fragmentation in teaching through technological tools. Therefore, to enable teachers to make the most appropriate choices for their students, training should focus on one technical function at a time, demonstrating how it can be used to address a particular difficulty exhibited by students with EFD as well as how it contributes to the technology's overall effectiveness. Based on the findings, it is also obvious that teachers and educators need to feel confident to raise their concerns explicitly during training, so training providers should provide appropriate opportunities for this and create a positive and constructive atmosphere.

Further implications for teacher education and EFD-specialised development programmes entail peer and mentor collaboration between teachers and other professionals, and undertaking active research to influence teacher progress. However, the present study's findings indicate that improving the awareness of EFD and harnessing the power of technology to address it goes beyond just developing research and theoretical aspects. Actual change in a mainstream setting requires both teacher-centred changes and reforms to the associated curriculum, teaching strategies and educational technologies. Previous studies, notably Allmankrah and Evers (2020), have emphasised the importance of broader educational reforms to overcome the issues of ineffective teaching methods and inadequate educational standards in Saudi Arabia, and this study demonstrates that teachers' input should be sought when designing specific educational reforms. Recognising teachers as an essential part of such reforms would encourage them to engage with them, to recognise their importance, and to take responsibility for enacting them to address their students' difficulties.

6.2.2 Implications for practice

EFD learner variability and the necessary related accommodations in a technology-mediated classroom are essential elements to be considered by school practitioners in an inclusive setting. However, understanding the extent and influence of the technology's role in cognitive processes training is a complex process. Observations in this study indicated that teachers' use of technology lacked consideration of specifications or context for individual students, and it was often challenging for teachers to communicate with each student on a one-to-one basis to practice the technology-based learning. Therefore, in their efforts to facilitate inclusive education in Saudi Arabia and integrate technological solutions, authorities should provide schools with diverse options for learning which can ameliorate this issue.

These resources should include different digital channels to address each student's difficulties, as well as developing teaching strategies that take multiple interactive preferences for learning (for example, visual and auditory) into account. Authorities also need to devise appropriate strategies for execution by teachers which recognise that students with EFD require more comprehensive guidance and teacher support to promote metacognition and to develop their EF skills (García-Campos et al., 2015).

6.2.2.1 Proposing a universal design for learning (UDL)

Considering the move towards a more mainstream inclusive setup in Saudi educational settings, a Universal Design for Learning (UDL) would appear to be a viable option to maintain a mainstream design effective for students with EFD (Wheeler, 2022). This design incorporates versatile learning variables, such as visual, auditory, or sensory–driven, considering students' strengths, weaknesses and preferences. Previous studies have broadly recognised the potential of the UDL framework as regards adopting a student-centred instructional framework, as it incorporates different iterations, including evidence-based practice, data-informed decisions for students, learning practices, and assessments, and contextual improvements in the learning environment (Basham et al., 2020).

Moreover, this recommendation recognises that UDL is a practical approach for students with learning and cognitive difficulties, especially in circumstances where there are fewer opportunities to develop an interactive setting which can accommodate their individual strengths, weaknesses and preferences (Basham et al., 2016). As Basham et al. (2020) explain, its effectiveness arises from through three core principles: multiple means of engagement, representation and action, and expression. These support multiple solutions and enable students to access and demonstrate their knowledge and skill acquisition in multiple ways. Thus, UDL in a technologically facilitated classroom context would be a viable option to address variability across students' preferences for learning, strengths, and EFD.

Aligning with the findings of Basham et al. (2020), UDL identifies the issues with practice that would enable teachers and practitioners to upgrade their teaching strategies and styles to accommodate modern digital solutions commensurate with the cognitive demands of their students. UDL could thus serve as a robust framework for inclusion, facilitating the use of technology, along with more traditional educational resources, to address diverse EFDs within a mainstream classroom setting. The findings of this study suggest that the adoption of such a framework would significantly enhance both support for students with EFD and the incorporation of technology within Saudi classrooms, and the authorities with responsibility for redesigning and making reforms through practical developments should consider the implications of its implementation in a Saudi educational context.

6.2.2.2 Developing an EFD-specific handbook

The development of a EFD-specific handbook which is accessible to all essential participants, including teachers, parents and practitioners, would increase awareness, improve confidence in the selection and implementation of interventions, and encourage collaboration between participants. The handbook should work as a home-school guide, outlining activities and strategies in light of theory and research, and developing a connection between teachers and parents to support the use of technological tools through collaborative actions. Policymakers should develop this practice by providing resources at the national level for better professional development in different inclusive schools.

Table 6-1: Implications and recommendations for good practice

Research question	Implications and recommendations for good practice
Research question 1: Lack of understanding of EFD to address and use technology effectively	• The Special Education Department of each school should design professional training programmes and devise a handbook after extensive analysis of teachers' current level of knowledge on EFD and use of technology (using primarily evidence of this current study and incorporating content from published literature, theories and contemporary practices in this context). • Training specific to teachers' development with regard to using technology relevant to EFD, by incorporating practical approaches • Involving teachers in designing EFD-specific training and development programmes • Technology-related professional development initiative in EFD-specific content instructions
Research question 2: Methods and strategies used by teachers to incorporate technology effectively (accommodations)	• More collaboration between general and special education teachers to co-facilitate and share ideas about using technological features more effectively • Considering possibility of strategies and approaches other than scaffolding that may be less challenging or requiring less one-to-one attention • Training teachers on cognitive task analysis • Authorities should provide better ways of assessing and measuring EF prior to execution of any programme or using any technological tool. For example, CogniFit enables professional tests to evaluate the level and extent of cognitive skills, such as IC, planning, cognitive flexibility, updating and WM. • Provision of and easy access to devices for both teachers and students, to facilitate one-on-one instruction for each student • Facilitating other resources such as workshops, conferences, collaboration of teachers with different professional learning communities (PLCs), distribution of documents (articles or books) which are EFD-specific, plus integrating technology as a mediator to meet these challenges

Research question 3: Contributions participants perceived related to the use of technology (affordances)	• Arranging workshops on developing insight into using basic in-built features and functions of iPads and other EF-specific tools and resources to address EFD (such as Notes, MS One Note, Calendar, Task Manager and Personal Organiser) • Developing specific Arabic versions of EFD-related applications, such as an Arabic version of technology resources supporting EF; these could include analogue timers, checklists, audio prompters, visual schedules and social stories. • Introducing modern, technologically-mediated intervention and cognitive training with more versatile functions of technology, such as Cogmed training for attention issues, which involves cognitive exercises, accessed on a computer, tablet or phone (Roche and Johnson, 2014) • Introducing better parent-teacher collaboration, for effective use of technology and realising its multiple affordances in different contexts

6.2.3 Implications for the further integration of technology

It is evident from the findings in this study that teachers were uncertain which students were struggling more with EFD diagnostically. Their inability to make this distinction impacts their ability to determine the appropriate use of technology; it may also affect their perception of the effectiveness of technology to address EFD if they make inappropriate instructional choices which do not result in the desired outcomes in learning or behaviour. This finding is therefore of concern, as it negatively impacts the learning and educational abilities of these students. Developing teachers' criticality skills to understand the underlying reasons for exhibited difficulties of students will help to better assess the root causes of EFD in particular. However, teachers and policymakers also need to consider the importance of potential indicators of EFD in students and employ appropriate diagnostic and assessment criteria.

In addition, in view of the present findings and those of previous studies, it is evident that the interaction between the learning environment and EF is somewhat dynamic and incorporates multiple factors which can change over time. The support pattern for students with EFD therefore depends both on the provision of appropriate devices and on determining the correct linkage and flow of accommodations, with levels of support adjusted as required. Considering the importance of teachers' role in this development, their critical understanding of different learning contexts for students with EFD, and the varying demands while using technology with these students, it is crucial for policymakers and other authorities working on introducing teacher-specific development programmes to consider these factors when promoting the further integration of technology into Saudi classrooms.

Furthermore, the findings suggest that some teachers' limited integration of technological tools and preference for traditional techniques may be influenced by their limited role in designing professional development programmes. This highlights a need for them to participate in the creation of developmental programmes and the need to provide hands-on training that improves two critical dimensions: firstly, developing teachers' preference towards about the effectiveness of using technology to support students with EFD and then determining the generalisation of improved EFD in different context through use of both traditional and technological tools ; and, secondly, strengthening the classroom learning environment by enhancing instructors' understanding of digital and EFD-specific skills, followed by eliminating distractions that impede effective learning for students with EFD. Teachers' limited integration of technology can be addressed by developing unique programmes and hiring educational technology coaches who specialise in educating teachers on using technology for students with EFD, as well as making better instructional choices for these students. However, teachers, practitioners and authorities should collaborate before implementing these measures. In this way, it is possible to identify all gaps and prerequisites for an interactive and varying support environment for students with EFD.

6.2.4 Implications for policymakers

The shift towards integrating technology into the classroom is driven by policy decisions linked to the overarching national strategy expressed in Vision 2030. As explained in Chapter 2 (see 2.2 and 2.3) a number of initiatives have been introduced to support this shift; however, this study indicates that further attention needs to be paid to supporting students with additional needs, such as EFD, especially in respect of teachers' ongoing professional development. Authorities, such as the MoE, involved in planning curricula should examine the gaps in mainstream instructors' awareness regarding EFD, increase teachers' competencies to support students with EFD, and strengthen current policies for students with cognitive difficulties in Saudi Arabia. The present study’s findings show that teachers are fundamental to a successful inclusive education system with effective technological structures; however, their understanding of EFD and the proper use of technology to address such issues are inadequate. Policymakers and legislative authorities need to address the issue of specialist professional development to enable teachers to achieve the desired outcomes in their specific educational context.

Policymakers in Saudi Arabia also need to develop interventions and formulate modern solutions specifically for EFD, including age-specific technological tools and interventions specific to each diagnostic group. They should also consider a proper framework for the systematic alignment of the specific needs of students with EFD and the various affordances of technology. Greater access to educational technologies specific to EFD should also be facilitated, including the provision of specialist IT support. As Antonenko et al. (2016) elaborate, this would enable educators and developers of technology to work collaboratively to align needs, abilities, and the affordances of technology to provide effective support for students with cognitive difficulties. For example, the affordance of focus could involve features in applications that help retain attention, and the affordance of sort-ability could allow sorting and deciding between different options to develop students organising and overall self-regulation skills. Closer collaboration would also promote the further development of specialist tools to assist in affordance assessment, which would enable better decisions about the selection and use of educational technology for students with EFD in inclusive mainstream settings.

Another important recommendation for the policymakers in light of the current study is to accommodate cognitive training exercises as these have been shown to reduce EFD through regular practice (Pasqualotto et al., 2021). Moreover, these exercises incorporate a variety of interventions using downloadable digital tools (preferably in Arabic), such as logical activities and games, and virtual simulations to enhance attention and WM. In addition to all these executions in the realm of technology for students with EFD, there should be a proper monitoring and follow-up framework to assist in keeping track of progress, implementation, and feedback on students' performance and improvement in EFD.

6.3 Constraints and limitations

Although this research study achieved its aims and objectives, it has some limitations, and sociocultural factors and unanticipated events, including the COVID-19 pandemic, constrained the methodology and findings. These are presented below.

Firstly, as a multiple case study research, this study had a relatively small number of participants – both teachers and parents. In total, 15 general and special education teachers from all three schools participated, as well as six parents. This sample size produced rich responses and information through semi-structured interviews; however, it limited the scope for identifying causal relationships that could be of significance, for example, by comparing teachers' demographics and their perspectives on the use of technology to address EFD. The small number of participants from each school also limits the generalisability of the findings to a broader context.

Secondly, there is a need for findings to be generalised to other geographical locations. The researcher collected data from three different schools in the Saudi capital, Riyadh; however, a more comprehensive picture could have been drawn if the north and south of the country had been included. Equally, incorporating schools from rural, suburban, and urban areas would have helped to identify socio-economic factors relevant to the study findings. However, time and budgetary constraints precluded this.

Thirdly, the most striking constraint during the research was the global COVID-19 pandemic. This caused the partial or complete closure of schools, limits on social interactions and restrictions on movements, which slowed the progress of data collection for some time. The observation sessions were completed prior to the pandemic, and some participants were interviewed before restrictions were imposed; however, other interviews had to be conducted via Teams or Zoom.

Research in Saudi Arabia also has to take into consideration various cultural and religious norms. As discussed in Chapter 3, gender segregation is mandatory in many different domains of education in the country, and, as the researcher is male, it was only possible for him to work with boys' schools. Therefore, all the students, teachers, and parents were male. Although the fathers offered valuable perspectives on EFD and the use of technology to support their children, input from mothers could have generated a more detailed and comprehensive picture. Also, the inclusion of female participants would have elucidated prevalence and contrast of SC characteristics across both genders and variations in enhancement of SC with use of digital technologies. This constraint limited the researchers' ability to fully investigate the parental perspective; it may also limit its findings to the Saudi context, as they may not be generalisable to other cultures or locations beyond the Gulf region.

6.4 Recommendations for future research

The fundamental contribution of the present research is associated with the fact that it has examined the use of technology to address EFD in different diagnostic groups from two perspectives i.e. teachers and parents. It has considered a range of variables, examining different devices and classroom set-ups across three different schools, and identified the importance of technology-based interventions related to specific age groups. However, a number of avenues remain open for further study.

It has been mentioned in Section 1.3 that terminology preferences for individuals with neurodiversity needs and cognitive challenges have been frequently neglected in published research, and that researchers, journals, and funding bodies, should regularly review and update their choice of language in line with the values of the relevant communities.

Similarly, there should be substantial efforts towards increasing awareness of EFD among teachers, pertinent professionals, and families of students with EFD. This requires proactive steps to improve their awareness regarding the role of EF, the behavioural aspects and cognitive functions affected in students with EFD, and how to use technology to support them more effectively in the academic domain. The provision of EF-specific training and courses to help teachers learn about technological accommodations and affordances is therefore a primary issue, and greater awareness-raising and cooperation with parents are also key.

Policymakers and authorities need to regulate their investment in the most appropriate domains, as identified by current research. There is a dearth of applications in Arabic that could specifically address the needs of students with EFD; therefore, investment in EFD-specific applications in Arabic should be proliferated. Furthermore, these Arabic-language applications should offer modification and customisation of relevant features that could help to manage the EFD of these students. While the topic of EF skills and complexities as a domain of inquiry has gained burgeoning attention, there is ample room for further study, notably in the Saudi context, where there is currently little research in this arena. This research is a first step in addressing this knowledge gap; however, in order to substantiate the initial findings produced in this study, there is a need for further investigation of varying aspects of technological efficacy. Furthermore, within the Saudi context, there is a need to explore ways of designing technology-enriched curricula that are developmentally appropriate, suitable for different age groups of students, and for effective integration of technology in the Saudi SEN context.

An obvious approach would be to address the gender imbalance in this study, either by conducting a similar study in girls' schools in Saudi Arabia, or in mixed classrooms elsewhere, and by involving mothers too. Moreover, the parental perspective in this study was limited to the general use of technology and not the actual practice with their child at home, and it may be productive to examine variations in technological usage at home and its impact on EFD.

The results of this study and the positive perceptions of teachers and parents demonstrate that students did perform better in various EFD-specific contexts through the mediation of technology. However, as Blair et al. (2018) note, realising long-term improvement in EFD involves embedding a consistent pattern of scaffolding support in the instructional context. Given the limited time frame of this study, it was not possible to determine whether the benefits obtained through the use of technology could be sustained beyond the end of the intervention. Future studies could therefore attempt to determine the retention of these improvements over time, and thereby identify the most effective and enduring solutions.

The findings of the current study have identified that despite the provision of funds by authorities, the technological integration is not as per required needs in the classrooms. Therefore, there should be an appropriate monitoring framework to ensure the distribution of funds in educational settings, which would require adopting a proper distribution approach to technological provision in the educational context.

Furthermore, the findings of the present study have not considered holistic aspects that may enable a more complete understanding of the role that technology plays in developing EFD. More research is required in this domain, using quantitative and qualitative measures to assess the maintenance of skills developed through technology relative to traditional approaches. Equally, the type of study undertaken does not facilitate establishing causal relationships, that is the causes and effects of certain factors. This requires a quantitative investigation in the context of EFD and the use of technology in future studies. Therefore future studies may need to set a minimum potential sample size so as to improve effect size and statistical power, which would enhance the validity and generalisability of results.

Finally, future research could incorporate broader and more variable issues regarding EFD compared to the current study. For example, future studies might incorporate more extensive and diverse samples, involving different geographic regions and other demographic characteristics, to assess causal relationships between EFD, technology and other aspects, and use data sources other than observation and semi-structured interviews. Further studies could also expand knowledge by conducting more quantitative research.

6.5 Concluding comments

In summary, using a range of technological affordances, capabilities and functions can help address different aspects of EFD, provided that instructors have the necessary knowledge and skills. However, future researchers need to consider developing teacher-oriented programmes that train them to execute strategies and support students with EFD through activities using technological tools. One of the main features identified through the findings is the motivation and reinforcement that technology provides to students with EFD. With its engaging and motivating features, they are more attentive and focused, and exhibit less challenging behaviour. Moreover, as previous studies have identified an increased affinity of students with EFD (across different diagnostic groups) towards technology, in future, policy-makers and ministries in Saudi Arabia should also consider the adoption of more advanced technological set-ups and solutions, such as virtual reality, robotics, artificial intelligence and augmented reality, to encourage a more bespoke and holistic learning environment for students with EFD.

Research efforts in this vein could also address the gap resulting from the fact that previous studies have not developed clear evidence showing the impact of technology-mediated cognitive training on EFD. The knowledge of EF developed through the present study's findings can be used to develop better levels of engagement and attentiveness in learning activities through the use of digital tools. In consideration of this feature of technology, EFD and motivation teachers and researchers in future can work on identifying ways of developing approaches to enhance motivation towards learning and EF development. Overall, research suggests that technologically-mediated learning of students with EFD directs them towards learning through various means, such as motivating and reinforcing, and sometimes by facilitating instructions.

A few final considerations are necessary to guide future endeavours. Firstly, EFD involves multiple challenges that cannot be addressed altogether and require one-to-one guidance and support from teachers, and technology-based learning requires particular attention from teachers. Thus, technology works differently for each school, depending upon the available features and teachers' understanding of its use in each context for students with EFD. Secondly, evidence is vital for informing technology-mediated practice and interactive features to address students' cognitive challenges and to improve their focus on learning. Thirdly, assessing EFD requires teachers' context and concept-specific knowledge that was lacking with regard to both teachers and parents; therefore, school authorities and policymakers need to develop assessment procedures to generate information that can be used to develop intervention and technological support for students with EFD. Lastly, technological tools, teachers' instructional strategies and guidance can successfully address EFD. However, more research is needed to identify other factors where technology-mediated learning and interventions could have more effect and improve overall EFD intervention in each diagnostic group. Overall, executive functioning is a foundational learning skill, and teachers in the Saudi context should be supported to develop professionally to improve students in this domain. Authorities should also facilitate necessary training provisions, access to resources, and better coordination with parents to develop better cognitive and academic milestones for students with EFD.

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Appendices

Appendix 1: Categories of technological tools i.e. high, medium and low-tech tools

Category	Characteristics	Examples
Low-tech	Non-electronic, easy to use and cost-effective	highlighter pencil grips, and large-print books
Medium-tech	Semi-electronic, easy to use and cost-effective	talking calculators, scanning pens, and portable keyboard, projectors (medium-high technology)
High-tech devices	Complex in design and use, electronic devices expensive and require expertise for effective use	communication devices, and speech recognition software

Table 6-2: Catagories of technological tools (Cited by Almethen, 2017)

Appendix 2: Techniques, their function and intended outcomes

Traditional tools/techniques+ technology	Function	Intended Skills to be addressed
Checklists	Determine the sequence of work for students	Address organising and managing skills
Colour coded workbooks	Help students visually engage with content and organise as per their choice	Enable memory improvement through visual content/ enable organising and managing
Highlighters	Memorising important text/ actual message	Draws attention and helps to memorise
Flashcard application	Customising student-friendly cards by selecting from subject and categories options	Improves working memory, self—regulation and independence

Appendix 3: Ethical Approval

University of Nottingham
UK | CHINA | MALAYSIA

School of Education
University of Nottingham
The Dearing Building
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educationresearchethics@nottingham.ac.uk

19/12/2019

Our Ref: 2019/54

Dear Khalid Alotaibi

Thank you for revising and resubmitting your research ethics application for your project:

Examining the Role of Scaffolding for Student with Executive Function (EF) Difficulties Using Technology in the Saudi Arabian Context: Teachers' and Parents' Perceptions

Our Ethics Committee has looked at your submission and has the following comments.

- We see this as a 'high risk' project, not as you state having two 'low risks', and ask you to be aware that researching with vulnerable young people with autism will always be seen as having a high risk in particular with respect to their ability to grant informed consent. We understand children are highly unlikely to be able to give informed consent. Your detailed account of the revisions has enabled a prompt response from the ethics committee.

Before your research can be approved, the Committee requests the following amendments are made:

- There is no date / timeline provided for this research. **Timeline provided for field work between 20th December 2019 and 12th March 2020.**
- There are a number of references to 'Autistic Children', 'ADHD Children'. We think it is preferable to refer to children with autism or children diagnosed with ADHD. **You have provided an explanation for your choice to described children in the way that you do. This is contested and will no doubt be a feature in your thesis.**
- While the intention is to focus on parents and teachers, the students should not be excluded from being asked to give consent / permission to participate. Parents are asked to give consent to observe students. This needs to be clearer and indicates a higher level of 'risk'. What age are the children / students? **We understand that the children might not be able to give informed consent. That is the reason for not asking. Your point that it is not 'necessarily' (sic) is not an adequate reason.**
- The form has not been completed correctly.
    - 1b – should be "no" as researching children with ADHD does constitute a sensitive topic, as this can be considered a disability. **Adjusted.**
    - 1d – should be "no" as a classroom is not a public space. **Adjusted.**
    - 4.1 – should be "yes" as it relates to children with learning difficulties. They are being observed and discussed, so they are participants as students with EF difficulties. Including these 'vulnerable participants' raises the risk to 'high'. If the researcher is observing teachers (teaching the students with EF difficulties) then the students are also in the research. **Adjusted.**

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    - The form does not make clear that children/students will be observed, whereas the consent form for parents does. The form and the documentation need to make clear that the children are participants in the research. **Amended.**
- It makes sense to produce documentation from templates, but in this case we are not sure that a copied information sheet (one of the reviewers had just read another) conveys confidence that the student has paid due regard to necessary sensitivities of engaging research participants. **Thank you for responding.**
- There remain a number of queries / errors in the Information sheet (parents / teachers)
    - One supervisor's family name is not written properly. **Corrected.**
    - Here, the researcher is asking parents for permission to given consent to observe the children at school. This needs to be noted and the excel form needs to be adjusted accordingly. **Corrected.**
    - Check matters relating to withdrawal from the study. Provide a date after which data will be used, analysed and presented in thesis, conference or other papers. **We strongly advise you to decide a date after which it will not be possible to withdraw i.e. after data have been analysed. At present you only deal with withdrawal prior to analysis.**
    - Could the parents be provided with a transcript and opportunity to check, verify their contributions? **Offered.**
    - The phrase 'The purpose of this study is to observe teachers and students' is not evident on the excel form. **Adjusted.**
    - The researcher needs to include details of the research ethics office. **Adjusted.**

- The GDPR form needs to be a version that refers to "Special category personal data" as the video recordings will uniquely identify participants and data concerning health. **Supplied.**

Based on the above assessment, it is deemed your research is:

- **Approved.**

We wish you well with your research.

Dr Kay Fuller
Ethics Chair

Appendix 4: Participant consent forms

PARTICIPANT CONSENT FORM (PARENTS)

Please read this page and sign if you agree to take part.

Research title: A study of the use of technology in teaching students with EFD in KSA: Teachers' and parents' perspectives in the Saudi context

Researcher: Khalid Alotaibi

Supervisors: Dr. Debra Costley and Dr. Jane Medwell

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential.
- I understand the procedures of the study, that I will participate in an online interview, and that I will be audio recorded during the interview on a separate device.
- I understand the procedures of the study, that my child will be observed in the classroom by the researcher.
- I understand that I have the right to my privacy respected and that all research data will be encrypted and stored in a password protected computer and the University of Nottingham (UoN) OneDrive, which only the researcher has access to.
- I understand that I may contact the researcher or the supervisor if I require further information about the research, and that I may contact the Research Ethics Coordinator of the School of Education, the University of Nottingham, if I wish to make a complaint relating to my involvement in the research.

I have read and understood the written details provided for me about the research, and agree to participate in the study. **Yes No** ☐ ☐

Signed ………………………………………………………………………………

Print name …………………………………………………………………………

I agree to my child being observed in school (please sign again if you agree). **Yes No** ☐ ☐

……………………………………………………………………… **Date** ……………………………………

Contact details

Researcher : **Khalid Alotaibi**. Phone: **+966554488211**.
Email: Khalid.Alotaibi1@nottingham.ac.uk

Supervisor : Dr. **Debra Costley**. Phone: +**044(0)1159513706**.
Email: ttzdmc@exmail.nottingham.ac.uk

The University of Nottingham, School of Education Research Ethics:
educationresearchethics@nottingham.ac.uk

- **Researchers to give the participant two copies of this form to sign. Participant keeps one and the researcher keeps the other.**
- **For any further information please do not hesitate to contact the researcher or the supervisor at the contact details provided above. If you have any complaints about how the research is conducted you can contact the School of Education Research Ethics Coordinator:** educationresearchethics@nottingham.ac.uk

PARTICIPANT CONSENT FORM (TEACHERS)

Please read this page and sign if you agree to take part.

Research title: A study of the use of technology in teaching students with EFD in KSA: Teachers' and parents' perspectives in the Saudi context

Researcher : Khalid Alotaibi

Supervisors : Dr. Debra Costley and Dr. Jane Medwell

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential.
- I understand the procedures of the study, that I will be observed and I will participate in an online interview, in a protected private room and that I will be audio recorded during the interview by a separate device.
- I understand the procedures of the study, that I will be observed in the classroom by the researcher.
- I understand that I have the right to my privacy respected and that all research data will be encrypted and stored in a password protected computer and the University of Nottingham (UoN) OneDrive, which only the researcher has access to.
- I understand that I may contact the researcher or the supervisor if I require further information about the research, and that I may contact the Research Ethics Coordinator of the School of Education, the University of Nottingham, if I wish to make a complaint relating to my involvement in the research.

I have read and understood the written details provided for me about the research, and agree to participate in the study.
Yes No ☐ ☐

Signed…………………………………. **Print name**……………………………………………………

Position ………………………………………………………………… Date ……………………….

PARTICIPANT CONSENT FORM (HEADTEACHERS)

Please read this page and sign if you agree to take part.

Research title : Examining the Role of Scaffolding for Students with Executive Function Difficulties Using Technology in the Saudi Arabian Context: Assessing Teachers' and Parents' Perceptions

Researcher : Khalid Alotaibi

Supervisors : Dr. Debra Costley and Dr. Jane Medwell

- I have reviewed the Participant Information Sheet and received a thorough explanation of the research project's purpose and nature. I had the opportunity to ask any questions I had regarding the study and they were answered to my satisfaction.
- I comprehend that the research will involve interviewing (teachers and parents) and observing (students, teachers) in the classroom. I also understand the purpose of the research project.
- I acknowledge that I have the option to withdraw from the study at any point, and this decision will not affect my current or future status.
- I understand that any information obtained during the study may be published but that my identity will not be disclosed, and my personal results will remain confidential.
- I understand that all recorded data will be securely stored in a password-protected UoN OneDrive file, and only the researcher and two supervisors will have access. All data will be stored for a minimum of seven years following publication, in accordance with the UoN data protection and GDPR policies.
- If I require more information regarding the research, I may contact the researcher or supervisor, and if I wish to make a complaint about my participation in the research, I may contact the Research Ethics Coordinator of the School of Education, University of Nottingham.

I have read and understood the written details provided for me about the research, and agree to participate in the study.

Signed ....

Print name ....

Position .... **Date** ....

Contact details
Researcher : Khalid Alotaibi. Phone: +966554488211. Email: Khalid.Alotaibi1@nottingham.ac.uk
Supervisor : Dr. Debra Costley. Phone: +044(0)1159513706. Email: ttzdmc@exmail.nottingham.ac.uk
The University of Nottingham, School of Education Research Ethics: educationresearchethics@nottingham.ac.uk

Appendix 5: Observation schedule - Field notes

Observation Schedule - Field notes

Teacher's name.. Primary School

Lesson: .... ***Time:*** .... ***Date:*** ....

Observed Period: .... ***Year:*** .... ***Number Student:*** ....

Technology Tools	
Observation points	My comments
Number of devices	
Type of devices	
Devices case	
Devices position in class	
Devices access ease	

Teacher	
Observation points	My comments
Introduction of Teaching	
Teaching method	
Interaction	
Eye contact with student	
Experience and knowledge of technology use	
Period of using devices in teaching	
Helping student if needed	
Teaching student in group or individual	
Effective use of device	
Communication skills	
Assessment of students' understanding	

Students	
Observation points	My comments
Interaction	
Following instructions	
Asking if does not know	
Devices position in class	
Knowing of technology use	
Extent level of difficulty in using device	

Scaffolding Activities	
Observation points	My comments
Teacher – student interaction	
Teacher using technology to scaffold the learning	
Scaffolding stages	

Other observation points:

- Location of school
- No. of classrooms
- Classroom layout/design:

Appendix 6: Information sheet for participants and headteachers

Information sheet for participants (Parents)

Research Title/Topic: A study of the use of technology in teaching students with EFD in KSA: Teachers and parents' perspective in Saudi context

Researcher's details:

My name is Khalid Alotaibi, and I am a PhD student at the University of Nottingham in the UK. My study title is "A study of the use of technology in teaching students with EFD in KSA: Teachers and parents' perspective in Saudi context. This research is under the supervision of Dr. Debra Costley and Dr. Jane Medwell in the School of Education at The University of Nottingham. It has gained ethical approval from the University of Nottingham.

Invitation to participate in the research:

I would like to invite you to participate in this study. You have been chosen as a potential participant as you are an important person who will have opinions and experience to share of relevance to this research. Your participation will be on a voluntary basis. Therefore, you have the right to stop your participation in this study at any time without giving any reason. I would appreciate it if you read and understand the purpose of undertaking this research and what it will involve, before you decide whether or not to participate this in study. If you prefer to gain more information or you have any question, please do not hesitate to contact me at Khalid.Alotaibi1@nottingham.ac.uk or on the phone +966554488211.

Aim of this research project

The purpose of this study is to observe teachers and students using iPads/tablets for learning in order to understand how they use them to improve achievement. Specifically, the study aims also to explore whether the use of technology devices like iPads or tablets are useful or not for students' learning. Additionally, I will examine the advantages and disadvantages of using these devices to support student learning in the classroom.

Participant requirements:

As a participant in this research, you will be asked to give your views and opinions in relation to the level of awareness the use of technology and how it might help to scaffold the learning of children with some learning difficulties. The interview will be carried out online at a time of your convenience. The interview will be online in a protected private room only between the researcher and the participant. The interview is expected to last for up to 45 minutes of your time, depending on how much you need to consider your statements and to respond. I will seek your consent for note-taking and audio recordings during the online interviews (using a separate device) in order to simplify the process of transcriptions. I will provide you with a transcript to make sure that your answers have been accurately transcribed. You will be also asked to provide your consent for observing your child during lesson which I will attend in the classroom.

Participants' rights:

Your involvement in this research is completely voluntary. You can also decide at any point of time during the study to withdraw from participating without any effect on the relationship of you and your child with the school or the researcher. Therefore, any data relating to you will not be part of the research as it will be deleted immediately if you withdraw before the data is analysed. You have the right to refuse to respond to any question if you wish so. You also have the right to ask any question arising from the interview guide.
If you have any concerns about how this research has been conducted you can contact my supervisor or the School of Education Research Ethics Coordinator, whose details are at the bottom of this paper.

What happens to the data?

All data from the research project will be treated with anonymity and confidentiality and you and your child will be given pseudonyms. In situations where the results of this study are published in international journals and discussed in conferences, you will remain anonymous. In the resulting thesis and any publications, pseudonyms will be used. The research data will be encrypted and stored in a password protected computer and the University of Nottingham (UoN) OneDrive, which only the researcher has access to. Should my supervisors need access to the data, this would be permitted if accessed in OneDrive. In line with the University's regulations, the research data will be kept for a period of 7 years. After this period, they will be permanently deleted.

Thank you very much for your help. We really appreciate it.

<table>
<tr><td colspan="2">Researcher's full name: Khalid Khatim Alotaibi
E-mail: Khalid.Alotaibi1@nottingham.ac.uk / Tel: +966554488211</td></tr>
<tr><td>Supervisors' full names:
Dr. Debra Costley
ttzdmc@exmail.nottingham.ac.uk
+44 (0)115 9513706

Dr. Jane Medwell
ttzjam@exmail.nottingham.ac.uk
+44 (0)115 9566480</td><td>Associate Professors of Education
School of Education
Dearing Building
Jubilee Campus
University of Nottingham
Nottingham, UK
http://www.nottingham.ac.uk/education</td></tr>
</table>

- **Researchers to give the participant two copies of this form to sign. Participant keeps one and the researcher keeps the other**

- **For any further information please do not hesitate to contact the researcher or the supervisor at the contact details provided above. If you have any complaints about how the research is conducted you can contact the School of Education Research Ethics Coordinator:** educationresearchethics@nottingham.ac.uk

Information sheet for participants (teachers)

Research Title/Topic: A study of the use of technology in teaching students with EFD in KSA: Teachers and parents' perspective in Saudi context

Researcher's details:

My name is Khalid Alotaibi, and I am a PhD student at the University of Nottingham in the UK. My study title is "*A study of the use of technology in teaching students with EFD in KSA: Teachers and parents' perspective in Saudi context*". This research is under the supervision of Dr. Debra Costley and Dr. Jane Medwell in the School of Education at The University of Nottingham. It has gained ethical approval from the University of Nottingham.

Invitation to participate in the research:

I would like to invite you to participate in this study. You have been chosen as a potential participant as you are an important person who will have opinions and experience to share of relevance to this research. Your participation will be on a voluntary basis. Therefore, you have the right to stop your participation in this study at any time without giving any reason. I would appreciate it if you read and understand the purpose of undertaking this research and what it will involve, before you decide whether or not to participate this in study. If you prefer to gain more information or you have any question, please do not hesitate to contact me at Khalid.Alotaibi1@nottingham.ac.uk or on the phone +966554488211.

Aim of this research project

The purpose of this study is to observe teachers and students using iPads/tablets for learning in order to understand how they use them to improve achievement. Specifically, the study aims also to explore whether the use of technology devices like iPads or tablets are useful or not for students learning. Additionally, I will examine the advantages and disadvantages of using these devices to support student learning in the classroom.

Participant requirements:

As a participant in this research, you will be asked to give your views and opinions in relation to the level of awareness the use of technology and how it might help to scaffold the learning of children with some learning difficulties. The interview will be carried out online at a time of your convenience. The interview will be online in a protected private room only between the researcher and the participant. The interview is expected to last for up to 45 minutes of your time, depending on how much you need to consider your statements and to respond. I will seek your consent for note-taking and audio recordings during the online interviews (using a separate device) in order to simplify the process of transcriptions. You will also be asked to provide consent to be observed during lessons which I will attend in the classroom. I will be observing one lesson at the beginning of the research and one at the end, at a time convenient to you.

Participants' rights:

Your involvement in this research is completely voluntary. You can also decide at any point of time during the study to withdraw from participating without any effect on the relationship of you with the school or the researcher. Therefore, any data relating to you will not be part of the research as it will be deleted immediately if you withdraw before the data is analysed. You have the right to refuse to respond to any question if you wish so. You also have the right to ask any question arising from the interview guide.

If you have any concerns about how this research has been conducted you can contact my supervisor or the School of Education Research Ethics Coordinator, whose details are at the bottom of this paper.

What happens to the data?

All data from the research project will be treated with anonymity and confidentiality and you will be given pseudonyms. In situations where the results of this study are published in international journals and discussed in conferences, you will remain anonymous. In the resulting thesis and any publications, pseudonyms will be used. The research data will be encrypted and stored in a password protected computer and the University of Nottingham (UoN) OneDrive, which only the researcher has access to. Should my supervisors need access to the data, this would be permitted if accessed in OneDrive. In line with the University's regulations, the research data will be kept for a period of 7 years. After this period, they will be permanently deleted.

Thank you very much for your help. We really appreciate it.

Researcher's full name: Khalid Khatim Alotaibi Khalid.Alotaibi1@nottingham.ac.uk +966554488211	
Supervisors' full names: Dr. Debra Costley ttzdmc@exmail.nottingham.ac.uk +44 (0)115 9513706 Dr. Jane Medwell ttzjam@exmail.nottingham.ac.uk +44 (0)115 9566480	Associate Professors of Education School of Education Dearing Building Jubilee Campus University Of Nottingham http://www.nottingham.ac.uk/education

- **Researchers to give the participant two copies of this form to sign. Participant keeps one and the researcher keeps the other**

- **For any further information please do not hesitate to contact the researcher or the supervisor at the contact details provided above. If you have any complaints about how the research is conducted you can contact the School of Education Research Ethics Coordinator:** educationresearchethics@nottingham.ac.uk

Information sheet for participants (Headteachers)

The University of Nottingham

Research Title/Topic: Examining the Role of Scaffolding for Students with Executive Function Difficulties Using Technology in the Saudi Arabian Context: Assessing Teachers' and Parents' Perceptions

Researcher's details:

My name is Khalid Alotaibi, and I am a PhD student at the University of Nottingham in the UK. My study title is "*Examining the Role of Scaffolding for Students with Executive Function Difficulties Using Technology in the Saudi Arabian Context: Assessing Teachers' and Parents' Perceptions*". This research is under the supervision of Dr. Debra Costley and Dr. Jane Medwel at school of education in Nottingham University. It has gained ethical approval from the University of Nottingham.

Invitation to participate in the research:

As you a headteacher of the school, I would like to invite teachers and parents to participate in this study on a project titled "*Examining the Role of Scaffolding for Students with Executive Function Difficulties Using Technology in the Saudi Arabian Context: Assessing Teachers' and Parents' Perceptions".* they have been chosen in this study as they are an important person who may have opinions and experience to share in this research. thier participation is on a voluntary basis. Therefore, you have the right to stop your participation in this study at any time without giving any excuse. I would appreciate it if you read and understand the purpose of undertaking this research and what will involve, before you decide whether or not to participate in this study. If you prefer to gain more information or you have any question, please do not hesitate to contact me at Khalid.Alotaibi1@nottingham.ac.uk or on the phone +966554488211.

Aim of this research project

The underlying notion of this study is to gain an investigation of understanding of how technology is used as a scaffolding mechanism to support students with EFD in the Saudi Arabian context. Specifically, the study will explore the level of how teachers and parents perceive the use of technology devices like iPads or tablets for children with EFD. It will also examine the benefit, opportunities and challenges of using these devices in engaging students with EFD. Finally, in this study, the researcher will also observe how teachers teach students with EFD using the technology.

Participant requirements:

As a headteacher of the school, participants (teachers and parents) in this research, will be demanded to participate their views and opinions in relation to the level of awareness that they have of EFDs in Saudi Arabia and how

Participant requirements:

As a headteacher of the school, participants (teachers and parents) in this research, will be demanded to participate their views and opinions in relation to the level of awareness that they have of EFDs in Saudi Arabia and how technology is used as a scaffolding mechanism to support students with EFDs. Teachers' teaching in the classroom will be observed to see how you teach students with EFDs using the technology. The interview will be carried out in time and place at your convenience. The interview is expected to last for up to 45 minutes of your time, depending on how much you need to consider your statements and to respond. I will seek your consent for note-taking and audio recordings during interviews in order to simplify the process of transcriptions. You will also be asked to provide consent to be observed during meetings/gatherings which I will attend.

Participants' rights:

You have the right to accept this invitation or not. You can also decide at any point of time during the study to withdraw from participating. You have the right to refuse to respond to any question if you wish so. You also have the right to ask any question arising from the interview guide. Even after you decide to take part, you have the right to withdraw at any time. The right to withdraw at any time from the research will in no way influence or adversely affect you as the participant.

What happens to the data?

All data from the research project will be treated with anonymity, confidentiality and pseudonymisation. In situations where the results of this study are published in international journals and discussed in conferences, you will remain anonymous. In the resulting thesis and any publications, pseudonyms will be used. The research data will be encrypted and stored in a password protected computer and the University of Nottingham (UoN) OneDrive, which only the researcher has access to. Should my supervisors need access to the data, this would be permitted if accessed in OneDrive. In line with the University's regulations, the research data will be kept for a period of 7 years. After this period, they will be permanently deleted.

Thank you very much for your help. We really appreciate it.

Researcher's full name:

Khalid Khatim Alotaibi
Khalid.Alotaibi1@nottingham.ac.uk
+966554488211

Supervisor's full name :

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Thank you very much for your help. We really appreciate it.

<table>
<tr><td colspan="2">Researcher's full name:

Khalid Khatim Alotaibi
Khalid.Alotaibi1@nottingham.ac.uk
+966554488211</td></tr>
<tr><td>Supervisor's full name :

Dr. Debra Costley
ttzdmc@exmail.nottingham.ac.uk

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Dr. Jane Medwell
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+44 (0)115 9566480</td><td>Associate Professor Education
School of Education
Dearing Building
Jubilee Campus
University Of Nottingham
http://www.nottingham.ac.uk/education</td></tr>
</table>

- **Researchers to give the participant two copies of this form to sign. Participant keeps one and the researcher keeps the other**
- **For any further information please do not hesitate to contact the researcher or the supervisor at the contact details provided above or contact with School of Education Research Ethics Coordinator: educationresearchethics@nottingham.ac.uk**

Appendix 7: Interview guides for teachers and parents

Interview Guide for Teachers

Ice breaking questions	1. How long have you been teaching in Education field? 2. How long have you been teaching in this school? 3. How long have you been teaching students with learning difficulties? 4. How long have you been teaching students with learning difficulties using technology in the classroom? 5. Have you experienced any person with executive function challenges before?
Research Questions	**Interview Questions and Probes**
To what extent are Saudi teachers and parents aware of the concept of EF challenges?	1. How much do you know about the concept of executive function as an issue for children with learning difficulties? 2. In what ways do you identify and differentiate students with executive function difficulties from other students? 3. As a teacher of SEN students, what are the main areas of executive function in your opinion?
How is technology being used to support students with EFD in KSA?	1. What is your preferred method for teaching children with executive function challenges: using technology devices (iPad/tablets) or a more traditional approach? 2. How many types of technologies do you have in the classrooms provided by authorities? And what are they?

	3. In what ways do you think that executive function skills can be improved by using technologies (iPad/tablets) in the classrooms? 4. In what ways do you think using technological tools help the children in overcoming academic challenges? 5. In what ways do you think that using technological devices (iPad/tablets) in teaching will help in improvement of executive function skills in children? Can you give me an example of how you use tablets to support EF skills?
What are the main contributions that parents and teachers see technology making to the learning of students with EF difficulties?	1. what improvements do you expect to see in the use of technologies (iPad/tablets) in classroom? 2. In what ways do you think that teaching students with executive functions difficulties by using iPads or Tablets supports their general learning? 3. In your experience do you think that the use of iPad/tablets for teaching could cause any barriers to learning for students with EF difficulties? 4. Have you encountered any challenges when using iPads or tablets in teaching students with executive function difficulties? If yes, please explain with examples. 5. Has the school given you the opportunity to join a training on how to effectively use technologies (iPad/tablets) in the teaching and learning process? If yes, explain how you found it.
Do you have any additional information that you would like to share?	

Interview Guide for Parents

Ice breaking questions	1. How many children do you have? 2. How many school-aged children do you have and what are their ages? 3. How many of your children attend this school? 4. Do any of your children have learning difficulties? If yes, how do the learning difficulties affect the child's education? 5. How do you try to address their learning difficulties?
Research Questions	**Interview Questions and Probes**
To what extent are Saudi teachers and parents aware of the concept of EF challenges?	1. Have you ever heard of the term executive function? If yes, can you give me a definition of what it means to you? If no, the researcher will give a brief description. 2. How much do you know about the concept of executive function as an issue for children? 3. In what ways does your child exhibit EF difficulties? Could you give me an example of how this is different to your other children? 4. In what ways does your child's teacher help them with their EF difficulties in the classroom?

<table>
<tr><td>How is technology being used to support students with EFD in KSA ?</td><td>1. Would you mind telling me what methods you prefer to be used when teaching your child in the classroom, for example using technology devices (iPad/tablets) or a more traditional approach?
2. Does your child use iPad and tablet tools in the classroom at the moment? If so, which/what types?
3. What do you know about the use of iPad and tablet tools in teaching your child in the classroom?
4. In what ways do you think that executive function skills can be improved by using technologies (iPad/tablets) in the classrooms?</td></tr>
<tr><td>What are the main contributions that parents and teachers see technology making to the learning of students with EF difficulties?</td><td>1. In what ways do you think using technological tools can help your child in overcoming academic challenges?
2. In what ways do you think that teaching students with executive functions difficulties by using iPads or Tablets supports their learning?
3. What, if any, concerns do you have about your child using iPad and tablets during the process of teaching?
4. Has your child encountered any challenges of using iPads or tablets in the learning process? If yes, please explain.</td></tr>
<tr><td colspan="2">Do you have any additional information about the use of technology in the classroom that you would like to share?</td></tr>
</table>