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USING SELF-REGULATED STRATEGY DEVELOPMENT TO IMPROVE THE FRACTIONS SKILLS OF STUDENTS WITH AVERAGE AND LOW MATHEMATICS ACHIEVEMENT

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AMAL AL SHABIBI

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A DISSERTATION APPROVED FOR THE

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BY THE COMMITTEE CONSISTING OF

Dr. Corey Peltier, Chair

Dr. Benjamin Heddy

Dr. Howard Crowson

Dr. Richard Velasco

Dedication

I dedicate this work to my mother, when I obtained the required score on the IELTS Test, she realized that I would travel far away from home to another continent. I saw in her eyes how that moment was heavy on her. To the soul of my beloved aunt, who passed away when I was here in the US. To my oldest sister, Asia, back in 2020, when I had depression, I told her I did not see a tomorrow in my life. She cried and said, “There will be lots of tomorrows in your life, in sha Allah”. To my beautiful family, my brother, sisters, sister in law, my lovely nieces and nephews. To Prof. Yasser Al-Hilawani, who encouraged me to pursue a doctoral degree in Special Education. He told me once, "I will keep sending recommendation letters to the universities till you get admission."

Finally, I dedicate this work to all dreamers. Keep dreaming, believe in yourself, work hard, and one day, you will achieve your dreams.

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Abstract

The study investigated the effectiveness of using Self-Regulation Strategy Development (SRSD) in teaching fraction skills using an experimental research design, specifically a switching replications design. The participants consisted of 62 eighth-grade students, identified with average and low mathematics achievement, selected from a school in Al Batinah South Governorate, Oman. The participants were selected from a sample based on their mathematics achievement levels and then randomly assigned to two conditions (treatment and control group). To collect data, screening measures, a pre-post-test on fraction skills, and a social validity questionnaire were used. The results show significant differences between groups in fraction scores after receiving the intervention, indicating the effectiveness of using SRSD in teaching fraction skills. Further, the study found that SRSD is effective in helping students in the treatment group maintain fraction skills one month after intervention. The results from the self-reported questionnaire showed that the students provided positive views about how beneficial the intervention was for them. The results were discussed in terms of the role of SRSD fractions in facilitating learning for students with different levels of academic achievement and how their differences in learning environments and pre-existing differences may affect knowledge fade.

Keywords: Self-regulation, fraction skills, mathematics achievement, students' perspectives

CHAPTER 1: INTRODUCTION

Mastering mathematics skills at an early age is essential; students' mathematics proficiency in Kindergarten predicted their mathematics proficiency in fifth grade (Ten Braak et al., 2022) and eighth grade (Claessens & Engel, 2013). Studies consistently find that elementary school students who struggle to acquire grade-level mathematics competencies encounter obstacles in mastering later mathematics competencies throughout their schooling years (Das & Janzen, 2004; Gibbs et al., 2018; Jordan et al., 2017). Additionally, these students may face challenges in accessing post-secondary educational opportunities and potential careers compared to their peers due to difficulties in mathematics (Das & Janzen, 2004). Hence, research has drawn educators' attention to improving the mathematics skills of elementary school students such as numerical symbol knowledge (Merkley & Ansari, 2016), counting, processing magnitudes (Moore & Geary, 2016), and whole number knowledge (Codding et al., 2016). As students progress through elementary school, research indicates that robust knowledge of rational numbers (i.e., fractions, decimals, percents) can be a new obstacle for students to acquire (Bailey et al., 2012) and serves as a strong predictor of success in middle and high school (Siegler et al., 2012). These outcomes imply that supporting students in acquiring mathematics skills at an early age could facilitate both their academic and practical lives in the future.

However, recent research demonstrated that the coronavirus pandemic affected students' mathematics learning. The coronavirus (COVID-19) has influenced individuals' lives worldwide in late December 2019 (El-Zoghby et al., 2020). Studies found that the restrictions related to reducing the virus outbreak impacted learning environments for students, forced schools to move to online or hybrid models of instruction, and these restrictions reduced the amount of in-person learning opportunities in regular classrooms (Doody & Keenan, 2021; Kim et al., 2021). Lewis and Kuhfeld (2021) investigated nationwide student performance on the NWEA MAP assessment administered in 2021-2022; they identified 9 to 11 percentile points regression in mathematics, significantly greater than reading (i.e., 3 to 7 percentile points). Furthermore, this regression was not experienced equally, with students from lower socioeconomic backgrounds and specific ethnic identities experiencing more significant regressions. Similar findings were brought by the Institute of Educational Sciences, National Center for Education Statistics (2021; 2023) after comparing students' performance on the National Assessment of Educational Progress in the USA before and after the pandemic, finding a drop in average mathematics scores among students in grades four and eight. Schult et al. (2022) attributed the reduction in students' scores in mathematics to a lack of financial support because some schools faced challenges in providing appropriate instruction during the pandemic. Additionally, Schult et al. (2022) found that the lack of accumulated experience in mathematics hinders students with low mathematics achievement from learning mathematics as they grow in their schooling years. All of this data indicates that school systems and educators must pay attention to the learning loss that occurred following the pandemic and the critical impact this had on students' mathematics knowledge which in turn would indicate a focus on high-quality instruction and intervention to support students' mathematical development.

Educators should be aware of several aspects that enrich the learning experience of elementary and middle students and support their success in mathematics in high school. Siegler et al. (2012) demonstrated that there is a relationship between students' achievement of fractions skills during their elementary school years and later performance in algebra in high school. This implies that students must build proficiency in core fractions skills as a part of learning development because it will support their later achievement in algebra.

Algebra is considered an important branch of mathematics that students need to succeed in to increase their opportunity to pursue a profession in science, technology, engineering, and math (STEM) trajectory in the future (Yoon & Strobel, 2017). However, research demonstrates that obtaining fractions knowledge is a specific stumbling block for many students (Hacker et al., 2019; Resnick et al., 2016; Torbeyns et al., 2015). Additionally, acquiring fraction skills is a challenge for many students in several schools worldwide (Torbeyns et al., 2015) because it demands many requirements. For instance, to acquire fractions knowledge students should be able to distinguish between whole numbers and the nature of fractions as part of a whole (Stafylidou & Vosniadou, 2004). A misapplication of whole number properties to fractions could hinder students from having appropriate fraction knowledge and impact their overall achievement in math as they grow in their schooling years (Jordan et al., 2017). This situation requires educators or investigators to provide students who struggle in math with effective interventions to improve their conceptual and procedural knowledge of fractions, supporting the students' later achievement in algebra and increasing their opportunity to pursue a profession in STEM areas.

Interventions Improve Fraction Skills

Systematic reviews employ a systematic method to minimize bias when evaluating studies, comprehensively investigating scientific literature related to a particular phenomenon. Systematic reviews are well-suited to provide evidence for effective interventions that enhance educational outcomes when aligned with specific parameters. For example, Roesslein and Codding (2019) reviewed the effectiveness of mathematics interventions focused on enhancing fraction knowledge of elementary school students identified with mathematics learning difficulties. The investigators found the most effective interventions consisted of multiple components, specifically, (a) the use of word problems for the application of skills, (b) the use of explicit instruction, and (c) the use of strategy instruction. Similar results were found in the reviews of both Siegler et al. (2010) and Fuchs et al. (2021) who recommended teachers use explicit instruction for teaching fractions. In their review, Fuchs et al. (2021) recommended teachers use explicit instruction when teaching students who struggle with mathematics to build fraction knowledge using concrete, and semi-concrete representations to connect them to abstract representations of mathematics. Siegler et al. (2010) recommended teachers use explicit strategies to help students solve fraction problems such as ratio and proportion word problems.

Explicit, systematic instruction guides students to problem-solving strategies step-by-step, allowing them to correct their responses to mathematics tasks with a cumulative review (Shin & Bryant, 2015). Therefore, many researchers use it as an intervention to teach fractions to students who struggle with learning mathematics (Fuchs et al., 2017) or students with learning disabilities (Gersten et al., 2009). The effectiveness of this type of instruction comes from employing multiple cognitive processes and promoting self-regulation strategies (Ennis & Losinski, 2019; Shin & Bryant, 2015; Gersten et al., 2009). This implies that self-regulation is crucial when teaching fractions, and educators should activate it when implementing explicit instruction.

Self-Regulation

Self-regulation is a multifaceted construct, including various behaviors performed by individuals from basic physiological activities to complicated purposeful cognitive processes (Bandura, 2001). Studies show a strong relationship between self-regulation and the learning outcomes of students in schools (Doabler et al., 2015; Schunk & Zimmerman, 2012) because self-regulated learning in contrast, involves individuals' ability to regulate their thinking, behavior, and emotions to achieve their learning goals (Johnson et al., 2021). For this reason, Lucangeli et al. (2019) recommended developing a training program based on self-regulation to improve the mathematics performance of students with dyscalculia.

The research field has provided investigators with several theoretical frameworks for self-regulation to promote students' learning over the last few years (Efklides, 2011; Pintrich 2000; Zimmerman, 2000). Zimmerman (2000), for example, developed a model of self-regulation consisting of three phases (a) the *Forethought phase*; (b) the *Performance phase*; and (c) *Self-Reflection*. Since then, the researchers used these three phases to outline a variety of components beneath each, such as task analysis (Zimmerman, 2013), self-motivation beliefs (Zimmerman et al., 1992; Oppong et al., 2019), self-control (Zimmerman, 2013), and self-observation (Hacker et al., 2019), and each of these four comprises many subcomponents related to cognitive skills. Cognitive skills facilitate learning mathematics and help students gain effective learning experiences (Cirino et al., 2016).

Harris and Graham (1999), also, developed another self-regulation model. The model of Harris and Graham (1999) is called *Self-Regulation Strategy Development* (SRSD), SRSD includes six phases that enable students to develop background knowledge, discuss the use of a specific strategy, model the strategy, memorize, and support the use of this strategy. The last phase of this model requires the student to practice the strategy independently.

Graham et al. (2012) demonstrated that interventions in SRSD writing improved the ability of elementary school students to produce writing with quality. Similarly, Ennis and Jolivette (2014) provided evidence that using self-regulation strategies enhanced the writing skills of students with emotional and behavioral disorders. In their meta-analysis of intervention on SRSD writing, Losinski et al. (2014) found a positive effect of the interventions on the outcomes of several writing skills (i.e., essay elements, quality, and word count) of students identified with emotional and behavioral disorders Additionally, using self-regulation enhanced the reading comprehension of students with learning disabilities (Sanders et al., 2019; Sanders & Garwood, 2022), disruptive behaviors (Sanders et al., 2022), and bilingual students with learning disabilities (Jozwik et al., 2019). Hence, these studies motivated Ennis and Losinski (2019) to use SRSD as a fundamental base for teaching fractions to students who struggle with mathematics.

Self-regulation Strategy Development Improve Fractions

Research provides evidence that using SRSD in teaching fractions skills improves the achievement of students identified with or at risk for mathematics disabilities (Haker et al., 2019; Losinski et al., 2019; 2021) because self-regulation enhances the motivational dynamics of learning (Trías et al., 2019).

Research demonstrated that many interventions on self-regulation were implemented for students with learning disabilities or mathematics difficulties (Lucangeli et al., 2019) students with or at risk for mathematics disabilities (Losinski et al., 2019; Hacker et al., 2019), students with emotional or behavioral disorders (Losinski et al., 2021), or students with mathematics disabilities (Hacker et al., 2019). However, a few studies implemented self-regulation for students with low achievement (Trías et al., 2019). Not to mention that the using SRSD for fractions (FILMS; CUT and EDIT) has never been implemented by investigators in Omani schools. Therefore, in the current study, the investigator will replicate the intervention of Losinski et al. (2019) in a group design for middle school students in Oman.

Study Purpose

This study aimed to partially replicate the intervention by Ennis and Losinski (2019), Losinski et al. (2019), and Losinski et al. (2021) but adapted to a group-based design to examine the effect of self-regulated strategy development (SRSD) on teaching fraction skills. The current study replicated the interventions on SRSD fractions (FILMS, CUT, EDIT). Still, it adapted them to a group design, focusing on eighth-grade students with average and low mathematics achievement (different cultural identities of the study participants), and using various measurement tools.

The study was implemented in a school in Al Batinah South Governorate in Oman. Oman is an Arabian country with a strategic location since it shares the Strait of Hormuz with Iran, providing the entire world with a sea route for ships from the Persian Gulf and Gulf of Oman to the Indian Ocean and China (Jones, 2012). Oman is a non-aligned country and mostly has a neutral foreign policy towards world issues, still, it has a tolerant policy (Daga, 2023). It has developed a great strategic partnership with the United States of America and maintains a peaceful relationship with its neighbors (Jones, 2012). Oman's population consists of people who originate from multiple ethnicities (Arab, Baluchis, Indian, or Zanzibari), explaining that some Omanis can speak several languages besides Arabic, such as Urdu, Baluchi, and Swahili (Al-Issa, 2020; Al-Maamari, 2016). However, the population consists mostly of Arabs, and Arabic is the official language in Oman (Al-Maamari, 2016). English is also spoken since the educational systems in Oman consider English Language Skills as one of the main curricula in Omani schools, and students should learn English from grade one through 12 since 1998 (Al-Mahrooqi & Denman, 2018). French and German are offered as choices to students after completing their tenth grade in school (Al-Issa, 2020). Making decisions related to individuals' lives in Oman is influenced by several factors, such as religion, the values of individuals and society, education, personal experiences (Katou et al., 2010), and the rules of tribes, sometimes (Al-Issa, 2020).

The education system in Oman includes public and private schools. The public schools in Oman are categorized into two levels of basic education (Cycle One and Cycle Two), followed by post-basic education, and learning at public schools is free for Omani citizens (Al-Salti & Haydar, 2020). Cycle one of basic education includes the students (boys and girls) from first to fourth grades. In fifth grade, females and males attend separate schools by moving to Cycle Two of basic education (Al Balushi & Griffiths, 2013). Post Basic education includes two school grades, eleventh and twelfth (Issan & Gomaa, 2010). In the current study, the investigator implemented the intervention for eighth-grade students who attended a Cycle Two school.

To conclude, replicating the previous studies but adapted to a group-based design with a different research setting could enrich the scientific field. According to Francis (2012) and Mackel et al. (2016), replicating studies provide the opportunity to extend previous studies and seek to confirm or validate their outcomes.

CHAPTER 2: REVIEW OF LITERATURE

Mathematics Performance

Ten Braak et al. (2022) found that early mastery of mathematics skills strongly predicts future success across multiple academic domains. Similarly, Claessens and Engel (2013) highlight the importance of early mathematics proficiency for primary school success, noting that mathematical achievement correlates with reading performance and socioemotional well-being in school. This underscores the critical role of early mathematics skills in shaping students' long-term academic achievement.

The National Assessment of Educational Progress (NAEP) mathematics assessment reported a decline in average mathematics scores among fourth and eighth-grade students in 2022 compared to 2019 (Institute of Educational Sciences, National Center for Education Statistics, 2023). Similarly, Lewis and Kuhfeld (2021) found that mathematics and reading achievement declined in students from grades 3 through 8, with a more significant drop in mathematics scores. They attributed this decline to the effect of the COVID-19 pandemic. In contrast, before the pandemic, the Trends in International Mathematics and Science Study (TIMSS) indicated that U.S. students' average mathematics scores in grades 4 and 8 remained relatively stable from 2015 to 2019 (Institute of Educational Sciences, National Center for Education Statistics, 2021). These findings suggest that the pandemic negatively affected students' mathematics achievement, reinforcing the need for effective mathematics instruction to support their academic progress

What Predicts Mathematics Achievement?

A review of the literature highlights several key factors associated with mathematics achievement. First, Morgan et al. (2009) found that children's mathematics knowledge at school entry strongly predicts their performance throughout primary education. Furthermore, research indicates that early mathematics proficiency in kindergarten significantly influences later achievement across various curriculum areas (Claessens & Engel, 2013; Hassinger-Das et al., 2014). Given this, young children should develop a solid mathematical foundation encompassing numerical symbol knowledge, including identification, cardinality, and ordinality (Merkley & Ansari, 2016). To support long-term academic success, Claessens and Engel (2013) recommend that educators emphasize early mathematics skills, pattern recognition, and measurement, as these foundational competencies contribute to students' ability to acquire more advanced concepts in later years.

Second, primary school students' early mathematics skills (i.e., counting, collecting items, and working with numerals) enhance their ability to process magnitudes, and such ability significantly predicts mathematical achievement (Moore & Geary, 2016). Furthermore, fraction knowledge has been identified as a crucial predictor of students' overall mathematics performance (Bailey et al., 2012). In their study, Bailey et al. (2012) examined the relationship between conceptual knowledge of fractions and mathematics achievement among sixth- and seventh-grade students using the Numerical Operations subtest from the Wechsler Individual Achievement Test, which includes tasks such as multi-digit arithmetic, rational number operations, and simple algebra problems. Their findings revealed that students' conceptual knowledge of fractions predicted their overall mathematics achievement in sixth grade, even after controlling for factors such as working memory and intelligence. Additionally, follow-up assessments indicated that fluency with computational fractions significantly predicted seventh-grade students' performance in whole number arithmetic, number fluency, and number line tasks.

Similar results were obtained by Siegler et al. (2012) when the investigators analyzed a large set of longitudinal data on fractions and mathematics achievement of elementary school students from both the United States and the United Kingdom. Their findings demonstrated that students' understanding of fractions and whole-number division in elementary school predicted their algebra knowledge and overall mathematics achievement in high school. Studies emphasize that students' performance in fractions in elementary school predicts their future performance in algebra, and algebra is a prerequisite knowledge to success in mathematics in high school. This signifies that enhancing students' competence in fractions skills contributes to facilitating their future mathematics success (Bailey et al., 2012), which serves as a mediator that opens the door for students to pursue a career in science, technology, engineering, and mathematics (STEM) programs (Cribbs et al., 2021).

Fractions Proficiency

Studies have found that acquiring fractions is a challenge for many students (Hacker et al., 2019) because it depends on their understanding of fraction concepts (Torbeyns et al., 2015; Resnick et al., 2016) and fraction magnitude (Resnick et al., 2016). According to Stafylidou and Vosniadou (2004), understanding fractions involves several components, such as: (a) distinguishing between the concept of fractions and that of natural numbers in their symbolic representation, and (b) understanding the relationship between the numerator and the denominator.

Jordan et al. (2017) conducted a longitudinal study on fraction learning that included students from grades three through six, highlighting a relationship between fraction knowledge and overall mathematics performance. The study found that a lack of fraction knowledge, such as (a) difficulty in estimating the location of fractions on a number line, (b) calculation fluency, and

(c) nonsymbolic proportional reasoning, negatively impacts students' performance on broad mathematics evaluations by the end of sixth grade.

Furthermore, several studies have found that learning fractions is particularly challenging because students often confuse fractions with whole number concepts (Yusof & Malone, 2003; Malone & Fuchs, 2017). Specifically, students with mathematical difficulties struggle to comprehend the characteristics of symbolic numerical magnitudes. These findings are supported by research showing that students at risk of underachieving in mathematics and those with learning disabilities face significant challenges in learning fractions (Al Shabibi & Alkharusi, 2018; Heemsoth & Heinze, 2014; Jordan et al., 2017; Otto & Kistner, 2017). These challenges highlight the need to provide targeted support through effective instructional strategies to help these students acquire fraction knowledge and improve their ability to solve mathematical problems.

Cognitive Research and Fractions

Studies indicate that promoting students’ achievement in mathematics requires logical progression in cognitive processes and arithmetic skills (Cirino et al., 2016; Peng & Kievit, 2020). According to Peng et al. (2019), the relationship between individuals' cognitive and academic skills becomes more measurable when students follow a systematic learning program in mathematics and language throughout their schooling. Cirino et al. (2016) found that cognitive abilities (i.e., working memory, language, and spatial skills), besides many mathematical skills, directly influence sixth-grade students' ability to acquire fraction skills and develop proportional reasoning. Similarly, Peng and Kievit (2020) found that cognitive skills (e.g., working memory, reasoning, and executive function) predict academic abilities, including reading and mathematics, and vice versa.

Executive functioning. Executive function includes several elements, such as working memory, flexible thinking, inhibition (Jefferson et al., 2006; Ten Braak et al., 2022), generation, planning, and sequencing (Jefferson et al., 2006). The variety of executive function components makes them play a substantial role in individual learning and academic achievement (Baggetta & Alexander, 2016). Hassinger-Das et al. (2014) found that the association between kindergarten and first-grade mathematical mastery is mediated partially by executive function and children's attention. Similar findings were reported by Ten Braak et al. (2022), who conducted a longitudinal study with 243 participants across three grade levels: kindergarten, first grade, and fifth grade. By the end of the study, the researchers suggested that executive function components (i.e., working memory, inhibition, and cognitive flexibility) serve as a key mechanism in strengthening the relationship between mathematics achievement and reading skills. This implies that the components of executive function are associated with students' learning and achievement.

Working memory. Working memory consists of a multi-component system that stores, manipulates, and manages data in short-term memory; hence, in mathematics tasks, working memory enables individuals to retain some information and use it to solve mathematics problems whenever needed (Cowan, 2008). Studies found that working memory is one of the executive function components that play a role in predicting mathematics achievement among children (Caviola et al., 2020; Miller-Cotto & Byrnes, 2020) and adolescent students (Caviola et al., 2020; Passolunghi et al., 2016). Additionally, a meta-analysis study conducted by Peng et al. (2016) found significant relationships between fraction performance and working memory. These fraction tasks required matching to a visual representation, fraction computations, and word problem-solving with fractions. This result demonstrates that working memory is crucial for mastering fraction skills.

Despite that, Studies found that students with low mathematics achievement have a deficit in working memory (Gathercole & Pickering, 2000; Klesczewski et al., 2015), leading to poor performance in mathematics or fractions skills. Given this, the literature suggests using cognitive strategies to support the capacity of working memory (Ilkowska & Engle, 2010; Hofmann et al., 2011), and improving their fractions skills.

Vocabulary/Language. Language is a structured system that individuals use to communicate using different methods involving speech and gestures (spoken language), signs, or written language (Evans & Levinson, 2009). In contrast, vocabulary knowledge is a complex construct requiring individuals to acquire several word knowledge components (Schmitt, 2014). Kramsch (2014); and Peng et al. (2020) found that oral and written language can facilitate people's learning and thinking. Peng et al. (2020) reported that language acquisition facilitates solving mathematics problems through working memory; hence, improving mathematics performance. On the other hand, Purpura et al. (2017) found that the mathematical language skills of children mediate the relationship between mathematics performance and later literacy skills. Furthermore, research shows that children rely heavily on language skills (oral and written) (Storch & Whitehurst, 2002; Jordan et al., 2017) when learning mathematics skills, such as counting and comparison (Jordan et al., 2017). In this regard, Peng and Lin (2019) reported that the effect of mathematics vocabulary on mathematics performance depends on the types of mathematics branches; they revealed that mathematics vocabulary learning is more important in specific mathematics domains than in others. For instance, according to studies, solving word problems about measurement and geometry depends on mathematics vocabulary more than numerical calculation after controlling for working memory and intelligence (Peng & Lin, 2019; Peng et al., 2020). These results indicate that if students have language learning problems (writing, reading, or both), they will face obstacles in solving verbal tasks in mathematics or fractions (Fuchs et al., 2017; Hacker et al., 2019).

Mathematics vocabulary. Mathematics vocabulary facilitates understanding, interpreting, and solving complex verbal mathematical problems (Nelson et al., 2020; Vesel & Robillard, 2013). Hence, a lack of linguistic vocabulary could hinder students with disabilities or students with low mathematics achievement (Forsyth & Powell, 2017) from comprehending or solving mathematics problems (Fuchs et al., 2017; Hacker et al., 2019). Thus, research recommends educators provide students with precise and accurate mathematics vocabulary embedded within learning strategies to help them achieve meaningful learning (Hughes et al., 2016; Riccomini et al., 2015).

Effective Instructions to Teach Fractions Skills

The Institute of Education Sciences (IES) is an arm of the Department of Education and focuses on the dissemination of recommendations to inform practice by evaluating educational research. Two systematic reviews conducted by IES focus on effective mathematics instruction to promote fraction skills (Siegler et al., 2010; Fuchs et al., 2021). Across both practice guides, we see actionable advice for teachers to use that will enhance fraction knowledge.

First, it is recommended to provide students with systematic instruction. This systematic instruction would involve explicit instruction, which refers to an instruction model focused on directly teaching new skills, enhancing student engagement in the learning process, and orienting students to find success (Archer & Hughes, 2010). As part of explicit instruction, explanations should build on students' prior knowledge. For fractions specifically, this instructional sequence will initially pivot off of students' informal understanding of sharing equal groups and creating equal proportions (i.e., through area models). Second, teachers should focus on using and promoting students' use of key mathematical language aligned with fractions. Developing strong vocabulary knowledge related to fractions will enhance students' conceptual knowledge that (a) fractions are numbers and how they relate to our whole number system, (b) the computational procedures we can employ when working with fractions, and (c) the ability to represent mathematical situations embedded within word problems in the abstract. In addition, using representations, such as manipulatives and number lines, is extremely beneficial for building conceptual knowledge of the mathematical concept along with procedural knowledge. The manipulatives, or number lines, help students build conceptual knowledge of something abstract. The integration of representations and abstracts from the beginning of the learning cycle is integral, and this has been referred to as the concrete-representational-abstract framework (viz., concrete-representational-abstract integrated; Morano et al., 2020). Furthermore, the IES recommends that practitioners challenge students to begin applying mathematical knowledge to word problems. This pushes students to identify how "real-world" situations can be represented mathematically and is a critical area for generalization. Last, they recommend the need to build students' fluency with declarative facts and procedures. When considering fraction knowledge, the two high-impact areas are fluency with (a) multiplication and division facts, which play an integral role in creating equivalent fractions and simplifying fractions to create equivalent fractions, and (b) fluency in creating equivalent fractions and comparing fractions to benchmark fractions (i.e., ¼, ½, ¾, 1). These recommendations should likely be embedded within an intervention program designed to enhance the fraction knowledge of students.

In another systematic review conducted by Shin and Bryant (2015), they have similar recommendations. Shin and Bryant (2015) synthesized the research findings of 17 studies to determine the most effective interventions on fraction skills for struggling learners in mathematics from grades 3 to 12. The authors found that interventions using (a) concrete and visual representations; (b) explicit, systematic instruction; (c) range and sequence of examples; (d) strategy instruction; and (e) use of word problems led to larger learning gains in fraction knowledge compared to studies that did not include these components. These findings were identical to a study conducted by Roesslein and Codding (2019), which reviewed 12 studies that investigated interventions to enhance fraction knowledge for elementary-aged students who were identified with mathematics difficulty. The outcomes of the study indicated that the most effective interventions included multiple intervention components, such as (a) explicit instruction, (b) concrete and visual representations, (c) range and sequence of examples, (d) strategy instruction, (e) student verbalization, and (f) word problems. Thus, these two systematic reviews and the IES practice guides all reached similar conclusions about the critical intervention components that should be included to enhance students' fraction knowledge.

In contrast, Misquitta (2011) obtained different results when examining the quality and effectiveness of studies published between 1990 and 18 years later; the investigator found that the concrete-representational-abstract framework, strategy instruction, and direct instruction are the most effective instruction in improving students' outcomes in fractions. In addition, Ennis and Losinski (2019) conducted a meta-analysis of 21 studies focused on teaching fractions to students with or at risk of disabilities using the 2014 Council for Exceptional Children Standards for Evidence-Based Practices in Special Education (CEC EBP) as a quality indicator; the investigators found that explicit instruction met the standards of CEC EBP as an evidence-based practice that affects students' outcomes (Long et al., 2021).

Given the preponderance of evidence for the benefits of explicit instruction and its impact on fraction knowledge, some have begun to draw parallels to explain what the driving force behind its effectiveness is. According to the studies, they found that using explicit instruction, in essence, relies on applying different cognitive processes and self-regulation strategies (Ennis & Losinski, 2019; Montague, 2007; Shin & Bryant, 2015). De Bruin and van Gog (2012) revealed that studies on metacognition skills provide evidence that self-regulation improves students' learning behavior. These results encourage Ennis and Losinski (2019) to recommend that researchers use self-regulation strategies when teaching fractions skills to students with or at risk of mathematics failure to improve their performance.

Self-Regulation

Self-regulation is an activation for using metacognitive knowledge (Chambres et al., 2002) and plays an essential role in critical thinking and student performance (Kourtidis, 2019). According to Zimmerman (2013), self-regulation refers to an individual's focus on learning processes to master learning, which entails a personal effort to gain knowledge and skills. In their definition, Johnson et al. (2021) go beyond individuals' ability to regulate their learning behavior to regulate their emotional behavior to achieve their learning goals.

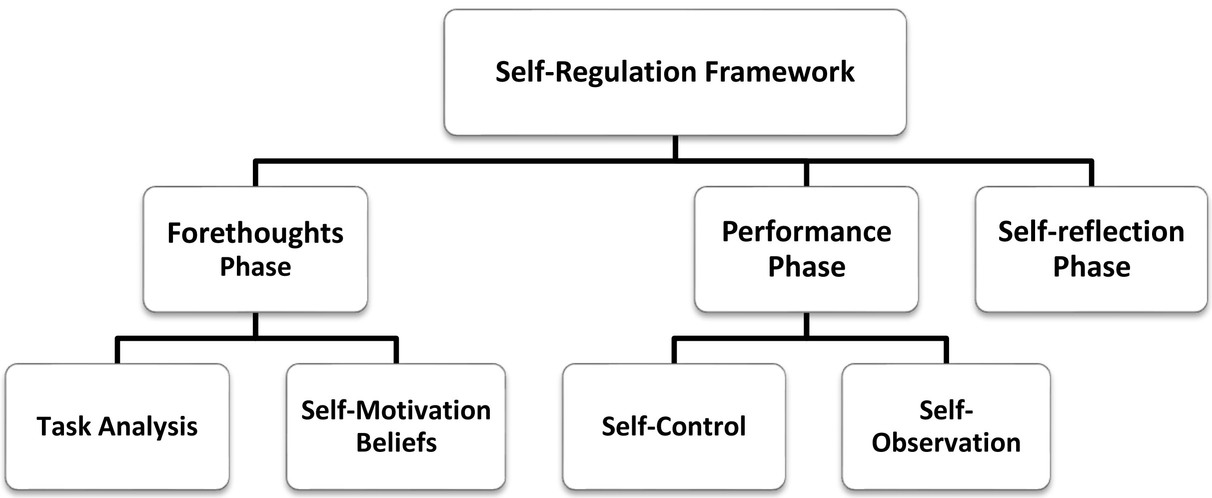
The research field has various definitions for self-regulation, leading researchers to develop several models for self-regulation to support students' learning (Efklides, 2011; Pintrich, 2000; Zimmerman, 2000). For example, Zimmerman (2000) developed a framework for self-regulation that includes several phases, encouraging researchers to add new components beneath each one. Another practical model for self-regulation was introduced by Harris and Graham (1999) to help educators improve students' learning behavior.

Self-Regulation Framework

According to Zimmerman (2000), self-regulation consists of three phases with multilayers of subcomponents, some of which were added by researchers from time to another to strengthen the model. The three phases include (a) the *Forethought phase*, (b) the *Performance phase*, and (c) *Self-Reflection*. Figure 1 demonstrates the framework phases.

Figure 1

A Self-Regulation Framework Developed by Zimmerman (2000)



First: Forethought Phase. This phase includes two components: *Task analysis* and *Self-motivation beliefs*. Task analysis skill involves two subcomponents: (a) goal setting, and (b) time management. Goal setting requires the learner to set several goals and subgoals that need to be achieved (Zimmerman, 2013). In contrast, a time management strategy involves planning processes, planning implementations, and self-evaluation (Altun & Erden, 2013). In the second component in the Forethought phase, self-motivational beliefs, Zimmerman et al. (1992)

revealed that the self-motivational beliefs of learners affect their oriented behaviors and explain their persistence when facing learning obstacles because it depends on two crucial elements: the personal goals of learners and their self-efficacy beliefs. Outcome expectations, task interest, and goal orientation are other subcomponents of self-motivational beliefs suggested later by Oppong et al. (2019).

Second: Performance Phase. The *Performance Phase* includes two categories: self-control and self-observation. In this phase, learners should implement strategies that affect their motivation and learning (Schunk & Zimmerman, 2012). Self-control refers to the individual's ability to direct their learning by using specific techniques whenever needed, such as self-instruction, attention focusing, task strategies, environmental structuring, help-seeking (Zimmerman, 2013), and imagery (Dunlosky et al., 2013). Not to mention that self-control of behavior requires individuals to self-observe and monitor their performance from one time to another (Hacker et al., 2009). In contrast, self-observation refers to metacognitive monitoring or recording specific aspects of an individual's behaviors (Kitsantas & Zimmerman, 2006). Zimmerman (2000) suggested that self-observation comprises two main subcomponents: metacognitive monitoring and self-recording. According to studies, metacognitive monitoring and self-recording are used by individuals to track their learning performance or progress (Ader, 2019; Hacker et al., 2009). However, metacognitive monitoring is an informal method for tracking the learning processes of individuals compared to self-recording, which includes formal records of learners created to achieve the same purpose (Hacker et al., 2009)

Third phase: Self-Reflection. During the third phase, self-reflection, an individual evaluates the determinants of success and failure using predetermined criteria to judge the overall learning performance (Zimmerman 2000). In this phase of self-regulation, the learners tend to evaluate themselves to improve their learning behavior and self-regulation (Schunk & Zimmerman, 2012). Self-reflection also involves individuals' self-reaction on whether they are satisfied with their performance and what sort of adaptation they should make in a similar learning experience (Zimmerman 2000).

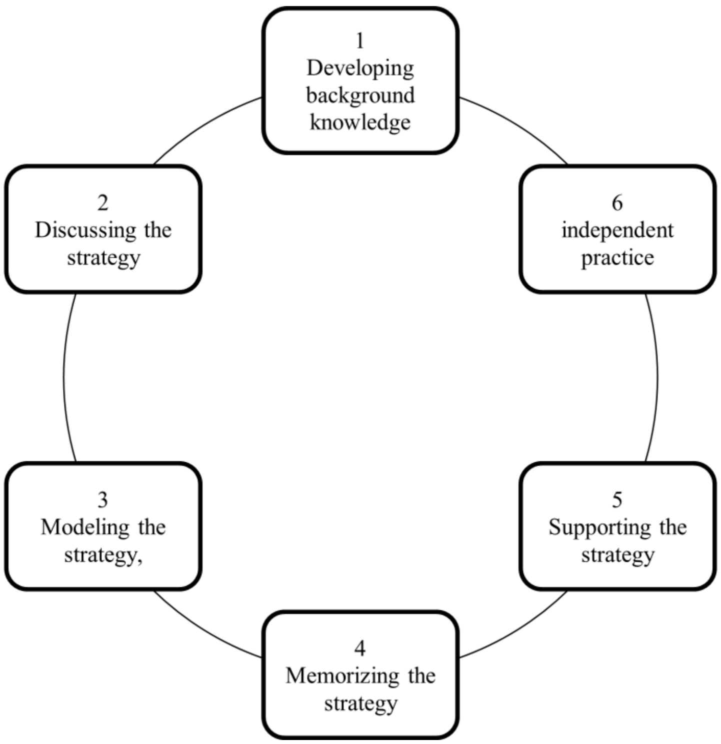
Self-Regulation Strategy Development Framework

Self-regulation strategy development is another framework that includes six stages. These six stages are used to provide students with self-regulation instructions to master specific learning skills by employing systematic procedures, and knowledge that lead them to an independent practice (Graham & Harris, 2018). First, the learners should develop background knowledge. Then, the learners discuss how to use the strategy, model it, memorize it, and support their use of the strategy. By the end of this model, learners should be able to employ the strategy in a learning situation independently (Harris & Graham, 1999).

The studies discuss the instructional phases of implementing an intervention using SRSD. Ennis and Losinski (2019) demonstrate that during the first stage, the interventionist should develop background knowledge with learners by discussing the most relevant vocabulary and concepts for learning a specific skill. In the second phase, they should explain to learners the importance of the strategy, what materials they need to acquire it, and how to employ it in a learning situation, encouraging them to commit to learning by signing a learning contract (Losinski et al., 2019). During the third phase, the interventionist models the strategy to learners step by step, incorporating thinking aloud with several components of self-regulation such as goal setting, self-monitoring (using a self-check) to assess their performance, self-questioning, and finally self-praise after completing the task (Harris et al., 2008). In the fourth phase, learners should practice memorizing the strategy steps using multiple assessment methods, such as oral or written quizzes, or they can use a self-check to assess their memory retention (Harris et al., 2008; Losinski et al., 2019). After that, the interventionist facilitates students practicing the strategy to support it (Mason et al., 2012). Finally, the learner should be able to employ the strategy of completing learning tasks without mnemonics or aid from the teacher or peers; at this point, the interventionist should approve their independence in the learning contract (Harris et al., 2008). Figure 2 demonstrates these steps.

Figure 2

A Framework for Self-Regulation Strategy Development



The instructional intervention on self-regulation strategy development was developed to improve students' learning behavior (Harris & Graham, 2009). Harris (2024) revealed that SRSD is employed in multiple academic areas, such as writing and reading, and recently, it has been used in mathematics research.

Self-Regulation and Academic Achievement

Research demonstrated a relationship between self-regulation components (i.e., goal setting, self-management, self-efficacy) and academic achievement (Zimmerman & Schunk, 2001). Mägi et al. (2016) reported that the relationship between self-regulation skills and cognitive skills showed a variation among individuals, and these differences can be reflected in their performance in academic skills (i.e., math and reading) as the individuals grow through their schooling years. Research found a connection between self-regulation skills and self-efficacy of individuals (Drake et al., 2014; Pintrich & De Groot, 1990); this relationship leads individuals with better self-regulation skills to experience a sense of efficacy when solving problems, increasing their ability to manage their emotions when they face challenges (Drake et al., 2014). In their study, Pintrich and De Groot (1990) found that self-efficacy and self-regulation work as predictors for the academic performance of students and their learning engagement. In contrast, individuals who lower learning engagement tend to make less effort in solving difficult academic tasks, resulting in a struggle in learning (Hughes et al., 2008). The outcomes of these studies imply that self-regulation has a positive correlation with enhancing the academic achievement of individuals.

Self-Regulation Improved Mathematics Achievement

Studies indicated a strong association between self-regulation and students' learning outcomes (Doabler et al., 2015; Schunk & Zimmerman, 2012). Lucangeli et al. (2019), for example, conducted an experimental study to investigate the effect of two mixed methods: (a) computer-assisted and pencil-and-paper intervention to improve mathematics skills; (b) self-regulation among students with dyscalculia from second grade through fifth grade. Their study found that the training program enhanced students' metacognition skills (i.e., self-regulation) and improved their mathematics achievement. Furthermore, Perels et al. (2009) found that using self-regulation interventions when teaching mathematics skills in regular classrooms to sixth-grade students influenced their mathematics achievement and increased self-regulation competencies. However, cognitive psychology research still provided researchers with little information on how to foster self-regulation in regular classrooms (de Bruin & van Gog, 2012). Accordingly, several studies recommended researchers and educators implement a self-regulated strategy development when teaching mathematics skills (i.e., the addition and subtraction of fractions with unlike denominators) for students at risk of mathematics disabilities to improve their performance in solving fractions tasks (Hacker et al., 2019; Losinski et al., 2019; 2021).

Self-Regulated Strategy Development for Fractions

Losinski et al. (2019; 2021) used the framework of SRSD (Harris & Graham, 1999) to develop instructional programs to teach fraction skills. Self-regulation strategy development includes six stages as a base to help students master fraction skills. Losinski et al. (2019; 2021) conducted a single-case research design in the two studies to evaluate the existence of a functional relation. The first study used multiple baselines across sites (Losinski et al., 2019), and the second used multiple baselines across students (Losinski et al., 2021).

In the study by Losinski et al. (2019), the investigators developed three sets of lesson plans (FILMS, CUT, and EDIT), and those lessons were associated with mnemonic devices to enable students to succeed in fraction skills. The three sets of lessons are as follows:

1. FILMS guides students in adding and subtracting fractions with unlike denominators (Losinski et al., 2019; 2021).
2. CUT leads students to learn how to simplify fractions.

3. EDIT instructs students to convert improper fractions into mixed numbers (Losinski et al., 2019).

Losinski et al. (2019) provided the intervention to students in small groups of four, seven, and nine students, respectively. In contrast, Losinski et al. (2021) provided the intervention sessions for each student individually (one-to-one). The outcomes of both studies show that using SRSD improves students' performance in acquiring and solving fractions skills (Losinski et al., 2019; 2021).

Similarly, Hacker et al. (2019) used the self-regulated strategy development model (Harris & Graham, 2009) to develop a metacognitive instructional intervention to teach foundational fractions concepts to students at risk or with mathematics learning disabilities. The study intervention focused on teaching FACT + R2C2 following the SRSD instructional strategy. FACT+R2C2 encompasses several procedures (Haker et al., 2019), requiring students to develop questions to solve mathematics tasks (Mevarech & Kramarski, 1997). The procedures of FACT+R2C2 are as follows:

1. FACT includes four components: Figure out a plan (F); Act on it (A); Compare your mathematical reasoning with a peer (C); and tie your responses together by writing arguments to support them (T).
2. R2C2 stands for Restate (R); Reasons (R); Students develop Counterclaims (C); and a Conclusion (C) to their arguments (Haker et al., 2019).

In the study of Haker et al. (2019), the interventionist team consisted of six general education teachers and four special education teachers, and all were trained to be qualified to introduce the intervention to the participants. The interventionist implemented FACT+R2C2 and encouraged students to ask several questions to promote their mathematics knowledge and solve fraction problems (Mevarech & Kramarski, 1997; Neuman & Schwarz, 1998). Meanwhile, students in the control group received daily instruction in their classroom (business as usual). By the end of the study, Hacker et al. (2019) found that students at risk or with mathematics learning disabilities in the intervention groups outgained the students in the control group, indicating the effect of using SRSD on improving the student's performance in fraction knowledge, mathematical reasoning, the number of argumentative elements, and total words written.

Overall, the three studies provided significant evidence that using SRSD in teaching fractions skills to students at risk or with mathematics disabilities improved their performance in solving fractions tasks (Losinski et al., 2019; 2021; Haker et al., 2019). Losinski et al. (2019) reported that using SRSD enhances students' deficits and strengths through affective, behavioral, motivational, cognitive, or metacognitive strategies. Trías et al. (2021) found that self-regulation strategies increase the motivational dynamics of learning, and motivation contributes to improving students' performance in mathematics (Shores & Shannon, 2007). This result concludes that using SRSD may lead students to success in learning fraction skills and solving related problems.

Limitations of Self-Regulation

Self-regulation involves the individual's responses to several situations or stimuli (Eisenberg et al., 2000), demanding the individual pay attention, manage their emotions and time, and exhibit behaviors that help them deal with these situations (Smith-Donald et al., 2007). Understanding and explaining learners' self-regulation requires investigators to be aware of several topics related to cognitive, behavioral, and social-cognitive theories (Zimmerman, 1990). The most common approaches to measure self-regulation include direct assessments, self-reports, or observational tools (Toering et al., 2012). These three common approaches provide cognitive psychology with beneficial information on self-regulation skills; however, each has limitations.

Direct assessment provides the research field with significant information on self-regulation skills of individuals (Smith-Donald et al., 2007); Despite, a low performance in an individual's performance on these assessments results in poor skills in self-regulation (Crozier and Perkins 2002), rather than attributing these poor skills to several reasons such as fatigue, anxiety, or any other reason (Duckworth & Yeager 2015). Similarly, self-report questionnaires in measuring self-regulation exhibit some weaknesses. The validity issue is a matter to discuss in this type of measurement since it is filled out by the learners themselves (Schellings Van Hout-Wolters, 2011; Toering et al., 2012) or other adults (i.e., their teachers), or parents (Mägi et al., 2016). In contrast, the validity of observational tools is stronger than self-report (Howard et al., 2019), but it takes a long time compared to direct assessment and self-report, and a few studies used this approach in assessing self-regulation skills (McCoy, 2019).

The outcomes of the studies on self-regulation rely on the measurements used, the understanding, and the explanation of the investigators of individuals' behaviors. Hence, replication of studies may serve to validate the findings of previous studies, and assess the generalizability of those findings to students with different identification, or to students who live in a different geographical area.

Replication Research

In this study, the investigator extended a single-case research design to a group design in the current study. Extending a single-case research design to a group design has several advantages, such as providing the investigators with a rigorous design that includes valuable pilot data before implementing the same intervention to a large group of individuals (Petry et al., 2011). On the other hand, single-case research design has several limitations, such as the external validity of the study outcomes (Horner et al., 2005). Hence, extending the single research to experimental group designs helps assess the generalizability of a single-case research design's outcomes for a large population (West et al., 2000). Additionally, internal validity is essential to show the causal inferences from the single research findings (Alnahdi, 2015), replicating a single design to a group design provides researchers with a better understanding of the effect size of an intervention since the group experimental design requires enough subjects and use two or more comparison groups to show the inference (Macgowan & Wong, 2014).

The evidence-based approach employs rigorous quality assurance and evaluation to ensure the fidelity and effectiveness of research replication in new practices (National Institute of Corrections [NIC], 2023). Jasny et al. (2011) defined replication as the independent verification of results and conclusions from one study in another. Replication is generally categorized into three types: direct, conceptual, and mixed (Mackel & Plucker, 2016), based on the study's purpose (Jones et al., 2010). Similarly, Jones et al. (2010) identify two additional types of replications beyond conceptual replication: exact and partial. Direct or exact replication seeks to confirm or validate the findings of the original researchers (Mackel & Plucker, 2014) by examining the same research construct using identical methods and measurements (Jones et al., 2010). In contrast, conceptual replication explores the same intervention construct but employs different methods and measurements to examine broader models and theories (Jones et al., 2010; Mackel et al., 2016). Partial or mixed replication investigates the same research construct while incorporating a combination of identical and modified methods and measures (Jones et al., 2010).

Replicating studies is crucial in the scientific field because it enables researchers to extend previous studies and validate their findings (Francis, 2012; Mackel et al., 2016). A lack of replication of the studies may increase bias in the research field, bringing questions about the validity of the outcomes (Cook, 2014). Not to mention that the bias in the studies' findings may be extended to narrowing the research literature (Begley & Ellis, 2012) and making critical decisions about some policies and educational practices based on them (Cook, 2014).

CHAPTER 3: METHODOLOGY

The current study employed a partial replication of Ennis and Losinski (2019); Losinski et al. (2019); and Losinski et al. (2021) by replicating the intervention of SRSD (FILMS, CUT, EDIT) in teaching fraction skills but adapting it to a group design, different measurement tools, the sample, and the cultural identity of the study participants. The current study aims to investigate the effect of self-regulated strategy development (SRSD) on teaching fraction skills to eighth-grade students in Oman with average and low mathematics achievement. Table 1 outlines the similarities and differences between the three and current studies.

Table 1

Partial/Mixed Replication of Prior Experiments

Characteristics	Losinski et al. (2019)	Ennis & Losinski (2019)	Losinski et al. (2021)	Current Study
Setting	Rural elementary schools in rural midwestern United States	A suburban elementary school in the southeastern United States	An elementary school in the Midwestern region of the United States	A middle school in the Al Batinah South governorate of Oman
Sample	Fifth-grade students identified as at risk for mathematics difficulty (9 girls, 7 boys)	Fifth-grade students identified as at risk for mathematics difficulties (3 girls, 5 boys)	Fifth-grade students identified with or at risk for emotional or behavioral disorders (3 males)	Eighth-grade students with average and low mathematics achievement (62 girls)
Design	Single-Case Research Design: A multiple-baseline design across schools	Single-Case Research Design: A multiple-baseline across-groups design	Single-Case Research Design: A multiple-baseline across students	A Group Desing: Extensions Design (switching replications design)
Intervention	SRSD with Fractions (FILMS, CUT, and EDIT) The intervention was delivered in small groups of four, seven, and five students.	SRSD with Fractions (FILMS, CUT, and EDIT) The intervention was delivered in small groups of three, three, and two students.	SRSD with Fractions (FILMS) The intervention provided a one-on-one	SRSD with Fractions (FILMS, CUT, and EDIT). The intervention was delivered to the treatment group (30 students), then after the first post-test, the intervention was

				delivered to the control group (32 students)
Dosage	10 intervention sessions. Time per session in schools 1, and3: 30min, and 45min in school 2)	10 intervention sessions, 30min per session	10 intervention sessions, 30min per session	15 intervention sessions, 40min per sessions
Measures	*Researcher Created Tool* 12 items reflecting: (a) addition and subtraction of fractions with unlike denominators, (b) simplifying fractions, and (d) converting improper fractions into mixed numbers. Scored as digits correct per 2 min	*Researcher Created Tool* 12 items reflecting: (a) addition and subtraction of fractions with unlike denominators, (b) simplifying fractions, and (d) converting improper fractions into mixed numbers. Scored as digits correct per 4 min	*Researcher Created Tool* 12 items reflecting: (a) addition and subtraction of fractions with unlike denominators. Scored as digits correct per 4 min	Investigator developed a pre-post-test in *Fraction Skills* 10 items to assess a student's ability to add and subtract fractions with unlike denominators, 5 items to simplify fractions, and 5 items to convert improper fractions into mixed numbers (40 minutes)

Research Questions

Four research questions guided this study:

1. What are the effects of Self-Regulation Strategy Development (FILMS, EDIT, and CUT) on the fraction performance of eighth-grade students with average and low mathematics achievement in Oman?
2. Does the control group's performance in solving fraction problems change after receiving Self-Regulation Strategy Development?
3. Was Self-Regulation Strategy Development effective at maintaining fraction skills 1 month after intervention?

4. What are the perspectives of eighth-grade students with low and average mathematics achievement on the learning setting, the learning material, and the strategies learned of SRSD after receiving the intervention?

The Study Hypotheses

The current research had three hypotheses:

1. Using a Self-Regulation Strategy Development (FILMS, EDIT, and CUT) in teaching fractions increases the performance of eighth-grade students in solving fractions problems.
2. Using the SRSD intervention (FILMS, EDIT, and CUT) to teach fractions effectively maintains the fraction skills one month after the intervention.
3. The control group's performance in solving fraction problems will change after receiving the Self-Regulation Strategy Development intervention.

The research question focused on the social validity from student perspectives of Self-Regulated Strategy Development was exploratory. I did not have a specific hypothesis for the results of these data but rather aimed to glean information that would inform the modification of the intervention to be more socially valid for practitioners in this context.

Research Design

The investigator selected an experimental research design, specifically a switching replications design. Switching replication design is useful because it enables the investigator to implement the intervention for all research groups (Hott et al., 2021). This design was appropriate because it requires participants to be randomized into groups, which allows for a causal test of the effectiveness of the intervention (Hott et al., 2021; Odom, 2021). Furthermore, I felt an ethical obligation to support all participants in acquiring pivotal fraction knowledge, and the switching replications design resulted in the "control" condition receiving the intervention at the end of the experiment. Switching replication design starts with a pretest and requires the investigator to divide the participants into treatment and control groups. First, the investigator provides the treatment group with an intervention. After the treatment group completed all intervention sessions, both groups received a posttest. Then, the groups were reversed, and at this phase, the participants in the control group should start receiving the intervention. Finally, all research groups received a second post-test. The second post-test in the Switching replications design provides the investigator with information about the effectiveness of the intervention for both groups and the maintenance effects for the treatment group (Hott et al., 2021). Table 2 illustrates the Timeline for the study design.

Table 2

Timeline for Conducting the Study Design

Group 1	Screening Measure Comp with Whole Numbers	Randomize to Condition N = 30	Pre-Test Fraction Skills Test	SRSD	Post-Test Fraction Skills Test	Business as Usual	Maintenance Fraction Skills Test
Group 2	Screening Measure Comp with Whole Numbers	Randomize to Condition N = 32	Pre-Test Fraction Skills Test	Business as Usual	Post-Test Fraction Skills Test	SRSD	Post-Test Fraction Skills Test
Time	October 2024	October 2024	October 2024	November 2024	November 2024	December 2024	December 2024

Note. Group 1 = intervention group, Group 2 = wait-list control group, Comp = computation, SRSD = self-regulated strategy development.

Setting

This study was conducted in the fall semester of 2024 at a public school in the Al Batinah South governorate of Oman. Public schools in Oman are categorized into two levels of basic education (Cycle One and Cycle Two), followed by post-basic education. Arabic is the official language of instruction in these schools. This research focused on a Cycle Two school, which includes students from grades five through ten, as the study targeted eighth-grade students.

The study population consisted of 140 eighth-grade students, with an average age of 12.76 ($SD = .58$). All possible participants were female, with 99% being Omani and 1% non-Arab. In terms of mathematics achievement, using students' mathematics scores from one year prior, 55% of the students were classified as average achievers (i.e., 89% to 65% in course math grade). In contrast, 24% were low achievers (below 65% in course math grade). Similarly, based on students' scores on Arabic Language Skills in seventh grade, 47% were average achievers (i.e., 89% to 65% in Arabic Language Skills course), and 10% were classified as low achievers (i.e., below 65% in Arabic Language Skills course). These percentages suggest that the majority of students in the study population did not face significant challenges with language skills such as reading and writing.

The intervention on fractions was administered to participants following a pretest. Initially, the treatment group received the intervention, while the control group continued their regular fraction lessons as outlined in the curriculum (business as usual). After completing the first phase, a post-test was conducted. Subsequently, the control group received the same intervention, while the treatment group resumed their standard lessons. All learning sessions were conducted in person, five days a week. A total of 15 intervention sessions were provided.

Each fraction lesson for the treatment group lasted no more than 40 minutes, in alignment with the standard class duration in Omani schools. The entire study was implemented over 12 weeks.

Sample

The study sample was drawn from a pool of eighth-grade students with average and low mathematics achievement who attend a school in Al-Batinah South governorate in the Sultanate of Oman. The school included four groups of students, distributed equally based on their different achievement levels to four classrooms.

The selection of possible participants relied on several criteria. First, the investigator used seventh-grade mathematics scores to determine students with average (C=79-65) and low achievement (below C= Below average), respectively. Second, the possible participants underwent several screening measures to evaluate their eligibility to participate in the study, such as *Computation Problems with Whole Numbers,* and their scores on Arabic Language Skills. Third, the investigator excluded all the students who passed the pretest (see below). Additionally, the investigator eliminated students who were diagnosed with mathematical learning disabilities, severe sensory problems, behavioral problems, or were receiving psychiatric treatment (Trías et al., 2021). Also, the study excluded students who struggle with reading or language to reduce the differences among the groups. The total number of possible participants who obtained (79-65) and below 65 was 74. The study excluded 2 students who moved to another school, 7 other students who did not give consent to participate in the study, and three students who were absent during the pre-test day.

Finally, the investigator assigned the four classrooms randomly into two conditions (i.e., 4 classes randomized to 2 conditions), putting seventh-grade mathematics scores of the two groups into the SPSS program. The results show no difference between the two conditions based on mathematics scores (p = .399). According to Hott et al. (2021), random assignment reduces the differences between groups, thereby increasing the likelihood of attributing study outcomes to the intervention. Table 3 outlines sample characteristics for each group

Table 3

The Study Sample Characteristics for the Treatment and Control Group

Groups	N	Gender	***Mean* (*SD*)**				
			Age	**Math Grade**	**Addition**	**Subtraction**	**Fraction[a]**
1	30	Females	12.70	64.83	89.00	33.57	2.03
			(.56)	(9.61)	(28.82)	(13.59)	(1.69)
2	32	Females	12.75	66.91	98.50	39.59	4.38
			(51)	(9.60)	(26.09)	(16.70)	(3.21)
Total	62	Females	12.73	65.90	93.90	36.68	3.24
			(.58)	(9.59)	(27.63)	(15.45)	(2.83)

Note. N = Sample Size; Group 1 = Treatment; Group 2 = Control.

[a]Pre-test scores.

Measures

Before implementing research measures, the investigator used the seventh-grade mathematics scores to determine low and average achievers. The current study uses instruments, mostly focusing on evaluating the conceptual and procedural knowledge of the study's participants. The research measures in the current study include screening measures and a pretest/post-test (same assessment) to measure the fraction skills performance. The dimensions of the *Fraction Skills Test* (pre/post-test).

The research gives investigators insight into different types of knowledge, including conceptual and procedural knowledge (Schneider & Stern, 2010; Schneider et al., 2011).

Conceptual knowledge provides individuals with fundamental knowledge about specific topics, connects the related information, and shows their relationships, while procedural knowledge demands that individuals follow several steps in sequence (Hiebert & Lefevre, 2013). The lack of conceptual knowledge and procedural fluency in mathematics can lead to academic struggles as students keep growing through different levels of schooling (Gibbs et al., 2018; Jordan et al., 2017). According to Hiebert and Lefevre (2013), conceptual knowledge is essential for understanding problems and then using the provided knowledge or strategies to solve them. In these terms, procedures could also be a part of that knowledge since the individuals activate them to develop steps to follow in sequence to help them solve problems (Sáenz, 2009). Additionally, procedural knowledge could lead investigators to gain more understanding about academic skills and provide the field of cognitive development with more information to be used later in solving problems and vice versa (Canobi & Bethune, 2008). This implies that procedural and conceptual knowledge are important and are both necessary to solve problems.

However, the use of procedural or conceptual knowledge in developing research measurements depends on the type of research, the topic to be assessed, and the subjects' age group (Schneider & Stern, 2010). Researchers have highlighted that it is difficult to disaggregate procedural knowledge versus conceptual knowledge when building mathematics measures to be used to evaluate intervention effectiveness (Rittle-Johnson & Star, 2007). Previous research on SRSD in mathematics has been conducted through single case research designs (SCRDs), which require the use of measures that are sensitive to change in short time frames (Barton et al., 2016). Thus, the previous SRSD fraction studies (Ennis & Losinski, 2019; Losinski et al., 2019; Losinski et al., 2021) targeted procedural knowledge, evaluating digits correct per minute on fraction tasks because these measures are easier to build and are expected to be sensitive in measuring learning in short time spans.

In the current study, the investigator focused on conceptual and procedural fraction knowledge to develop a research instrument (the pre-post-test) for assessing the effect of intervention on improving students' fraction skills performance. Evaluating the effectiveness of an instructional program concerning conceptual and procedural fraction knowledge requires testing the validity of the assessment in measuring the differences (Lenz et al. 2020) in fraction skills performance between the two groups of the study. However, the research field did not determine specific standards that can be used to evaluate the validity of those measures (Schneider & Stern, 2010). See below for more details about the study instruments.

Screening Measures

The investigator conducted two tests related to *Computations with Whole Numbers* to evaluate the basic calculation facts of possible participants.

Computation Problems with Whole Numbers. The assessment consists of two tests on two skills: addition to 18 and subtraction from 18 (M.I.N.D.: Resources for Early Numeracy & Computation Skills, 2017). The two tests require students to solve as many problems as possible within 1 minute to assess their fluency in the whole numbers of mathematics facts. Problems will be scored based on the number of correct digits, for example, 3+3=6 is scored as one correct digit, and 3+8=11 is scored as two correct digits. To pass the addition and subtraction tests, students should answer 31 digits correctly per minute (Burns, VanDerHeyden & Jiban, 2006) with 95% accuracy. Internal consistency reliability coefficients were .97 and .94 for the *Addition* and *Subtraction Tests* as measured by Cronbach's alpha.

Pretest/ Post-test in Fraction Skills

The investigator followed the Ministry of Education in Oman's established procedures to develop the *Fraction Skills Test* (pre/post-test) in alignment with national policies for assessing mathematics skills. In August 2023, the Ministry updated its official guidelines for evaluating mathematics skill mastery among students in grades seven through nine in Oman's public schools. These guidelines instruct educators to consider various cognitive domains and difficulty levels when designing test items. Accordingly, the test items must align with three cognitive domains of Bloom's taxonomy: knowledge, application, and reasoning; each is assigned specific percentage distributions to determine overall difficulty levels.

Bloom's Taxonomy of the Cognitive Domain consists of six levels, ranging from basic recall of information to complex critical reasoning skills (DeWaelsche, 2015). Knowledge represents the lowest level of learning outcomes in this framework (Żywno, 2003), requiring students to recall facts or previously learned material (Das et al., 2022). In contrast, applied questions involve mathematical problems derived from real-world contexts outside pure mathematics, incorporating mathematical concepts, methods, and problem-solving strategies (Blum & Niss, 1991). Reasoning questions, on the other hand, require students to solve non-routine mathematical problems that demand analysis, generalization, integration, justification, or explanation of their answers (Rizta et al., 2013). Table 4 presents the distribution of test items according to cognitive domains, their respective percentages, and the scoring points for each item, as outlined in the Ministry of Education in Oman guidelines.

Table 4

The Components of the Fraction Skills Assessment for Students in Eighth Grade

Fractions Skills	Cognition Domains			Total items
	Knowledge Questions (40%)	Application Questions (40%)	Reasoning Questions (20%)	
Addition with Fractions	2	2	1	5
Subtraction with Fractions	2	2	1	5
Simplifying fractions	2	2	1	5
Converting improper fractions into mixed numbers	2	2	1	5
Total Items	8	8	4	20

The investigator used one assessment to evaluate both pretest and post-test, consisting of four fraction skills: Fraction computation (addition and subtraction with fractions), simplifying fractions, and converting improper fractions into mixed numbers. Knowledge questions require conceptual knowledge, application requires procedural knowledge, and reasoning questions require both to solve fraction problems.

Inclusion and Exclusion Criteria

Table 4 shows that the Fraction Skills Test consists of 20 items in this study, divided into 10 items for fraction computation and 5 for each simplifying fraction and converting improper fractions into mixed numbers. In other words, the test was divided into two subsets with 10 points for each subtest to minimize testing fatigue. The range of possible scores is from 0 to 20. The students should fail the *Pretest on Fraction Skills* to be eligible to participate in the study.

If the students master a skill, they should obtain at least a score of 4 or 5 correct responses to each skill. Accordingly, if the students master 3 or 4 out of 4 skills they will be excluded.

Before giving the *Fraction Skills Test* to the study participants, after refining the test's items, the investigator conducted a pilot study to assess the validity and reliability of the fraction. The students who participated in the pilot study attended a different school in Al Baitnah South Governorate, not the same school where the study was conducted. The total number of students who took the test was 34.

Validity and Reliability of the Test. To ensure the validity of the test, a panel of experts from educational measurement and mathematics education reviewed the test items regarding clarity, relevance to the measured construct, appropriateness for the target participants, and alignment with the Omani mathematics curriculum. Their feedback was used to refine the test items. Additionally, the investigator assessed the correlation coefficient among the test dimensions. Table 5 summarizes the result.

Table 5

The Correlation among the Fraction Test dimensions.

			95% Confidence Interval for Difference	
Scale Dimensions	**Pearson Correlation**	**Sig. (2-tailed)**	**Lower Bound**	**Upper Bound**
D1-D2	.680	<.001	.444	.828
D1-D3	.600	<.001	.328	.780
D1-D4	.811	<.001	.652	.902
D1-DT	.905	<.001	.817	.952
D2-D3	.691	<.001	.460	.834
D2-D4	.628	<.001	.368	.797
D-2-DT	.852	<.001	.722	.924
D3-D4	.556	<.001	.269	.753
D3-DT	.818	<.001	.663	.905
D4-DT	.878	<.001	.767	.938

Note. N = 34; D1= Addition with Fractions; D2= Subtraction with Fractions; D3= Simplifying fractions; D4= Converting improper fractions into mixed numbers; DT= Total score.

Table 5 shows a significant association between scale dimensions for the four dimensions of the scale (p <.001). The highest correlation coefficient of the scale dimensions is between the first dimension (addition with fractions) and the fourth (converting improper fractions into mixed numbers) (r = .81), indicating a positive and strong relationship, with 95% CI [.65, .90]. In contrast, the lowest coefficient correlation is between the third dimension (simplifying fractions) and the fourth (converting improper fractions into mixed numbers) (r = .56), indicating a moderate relationship with 95% CI [.27, .75]. Pearson product-moment correlation coefficients of the four dimensions with the total score ranged between .82 and.91 (p <.001), indicating a high degree of construct validity.

The internal consistency reliability coefficient for the pilot was .90, measured by Cronbach's alpha. The reliability of students included in this experiment on the pre-test, the first post-test, and the second post-test are .70, .90, and .84, respectively). Appendix B shows the test details.

Social Validity Questionnaire

For social validity, the study used a questionnaire comprising 15 items rated on a 5-point Likert-type scale (5 = always to 1 = never) and one open-ended question. The questionnaire's items fall into three distinct dimensions: the learning setting, the learning materials, and the strategies learned) as shown in Appendix C. This questionnaire was given to the study participants to evaluate the intervention and provide their opinions after completing all the learning sessions.

Validity and Reliability of the Questionnaire. A panel of experts from the Educational Department reviewed the test items regarding clarity, relevance to the measured construct, appropriateness for the target participants, and alignment with the intervention content. Their feedback was used to refine the test items. Additionally, the investigator assessed the correlation coefficient among the test dimensions. Table 6 outlines the result.

Table 6

The Correlation among the Dimensions of the Social Validity Questionnaire.

			95% Confidence Interval for Difference	
Scale Dimensions	**Pearson Correlation**	**Sig. (2-tailed)**	**Lower Bound**	**Upper Bound**
D1-D2	.538	<.001	.333	.694
D1-D3	.592	<.001	.402	.734
D1-DT	.848	<.001	.759	.906
D2-D3	.454	<.001	.231	.632
D-2-DT	.763	<.001	.634	.851
D3-DT	.865	<.001	.785	.917

Note. *N* = 62; D1 = The learning setting; D2 = The learning materials; D3 = The strategies learned; DT = Total score.

Table 6 shows a significant association between questionnaire dimensions for the three dimensions of the scale (p <.001). The highest correlation coefficient of the scale dimensions is between the first (the learning setting) and the third dimension (the strategies learned) (r = .59), indicating a positive and moderate relationship with 95% CI [.76, .91]. In contrast, the lowest correlation coefficient is between the second (the learning materials) and the third dimension (the strategies learned) (r = .45), indicating, also, a moderate relationship with 95% CI [.23, .63]. Pearson product-moment correlation coefficients of the three dimensions with the total score ranged between .76 and.86 (p < .001), indicating a high degree of construct validity.

The internal consistency reliability coefficient was .77, measured using Cronbach's alpha.

Procedural Fidelity Checklist

For the Fidelity of Treatment, the investigator used a checklist. The checklist consisted of 14-17 items distributed into three dimensions. The items in the second dimension differ from one checklist to another to assess the teaching procedures using SRSD fractions. The checklist has only two possible responses: Yes (1) or No (0). Appendix D shows the checklist dimensions and the related items.

Intervention

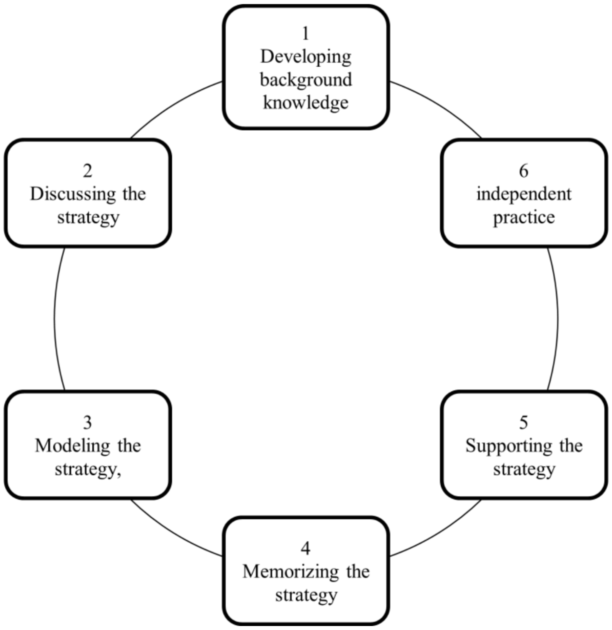
To address the research questions, the investigator conducted an experimental research design using the Extended Design, specifically the switching replications design. This approach involved implementing self-regulated strategy development to enhance students' performance in solving fraction problems.

Self-Regulated Strategy Development Intervention for Fraction

Self-regulation strategy development is a framework that includes six stages that require developing background knowledge, discussing the use of a specific strategy, modeling, memorizing, supporting the use of this strategy, and then the independent practice of this strategy (Harris & Graham, 1999). The figure below demonstrates these steps.

Figure 3

A Framework for Self-Regulation Strategy Development



For the study intervention, the investigator adapted SRSD for fractions (FILMS, CUT, EDIT) (Losinski et al., 2021). Losinski et al. (2019) developed three sets of lesson plans (FILMS, CUT, and EDIT), and connected them with mnemonic devices to help students succeed in skills such as: (a) adding and subtraction fractions with unlike denominators; (b) simplifying fractions, and (c) convert improper fractions into mixed numbers.

FILMS. The first set of lessons focuses on fraction calculation, specifically, adding and subtracting fractions with unlike denominators; hence, the strategy consists of five steps to guide students in adding and subtracting fractions with unlike denominators. In the first step F, in step, the students will be required to find the denominator. The second step is I, asking the students to identify the multiples. The third step is L, requiring the students to locate the least common multiple. Then, M stands for multiply, asking the students to multiply the fractions by the least common multiple to make new fractions. The final step is S, which demands the students solve the problem by adding the numerators and carrying the new denominator across (Losinski et al., 2021; 2019)

CUT. Reducing fractions is the focus of the second set of lessons. Hence, the CUT sets help students learn how to simplify fractions. In addition, the mnemonic CUT was developed by Losinski et al. (2019) to help students master the skill. CUT consists of three actions. First, the letter C stands for Calculating the factors, U stands for Underline the greatest common factor (GCF), and the final letter T indicates the time to divide the numerator and denominator by the GCF.

EDIT. The final sets teach the students how to convert improper fractions into mixed numbers. EDIT comprises four steps: (a) the student examines if the numerator is greater than the denominator; (b) divides the numerator by the denominator; (c) Inserts the quotient as a whole number; and finally (d), the student Turns the remainder into the new numerator.

The lesson plans (FILMS, CUT, and EDIT) were associated with several activities to support students' learning of the three basic skills and help the students succeed in fraction skills.

Procedures

The procedure used in the current study was as follows:

1. The investigator obtained the IRB approval to conduct the study
2. The investigator obtained approval to conduct the study at a Cycle Two school in AL Batinah South Governorate in Oman,
3. The investigator used the seventh-grade mathematics scores to determine low and average school achievers. The school placed students into four classrooms to ensure they were equally distributed based on their seventh-grade scores across academic domains (e.g., mathematics, Arabic, English skills).

4. The investigator administered the screening measures to all students identified as average or low achievement in mathematics (i.e., <80 math score in seventh grade) in the four classrooms to identify eligible participants.
5. The investigator randomly assigned the four classrooms to two conditions (treatment and control group).
6. The investigator administered the pretest to all eligible participants.
7. The investigator obtained the required consent from possible participants.
8. The treatment group received three types of intervention: FILMS, CUT, and EDIT to master fraction calculations, simplify fractions, and convert improper fractions into mixed numbers, respectively. In contrast, the control group received the lessons on fractions as planned in their regular curriculum (business as usual). Table 7 demonstrates the timeline for implementation of the intervention sessions.
9. After completing all the intervention sessions for the treatment group, the investigator administered a post-test for all research participants.
10. The groups were reversed, and at this phase, the participants in the control group should start receiving the intervention.
11. All research groups received a second post-test.

Table 7

Lessons Introduced by Week

Weeks	Sessions	Intervention Lessons
1		FILMS (Fractions Calculation)
	1	Introduce FILMS
	2	Model FILMS
	3	Collaborative Practice
	4	Peer Practice
	5	Fading Supports to Independence
2		CUT (Simplify Fractions)
	6	Introduce CUT
	7	Model CUT
	8	Collaborative Practice
	9	Peer Practice
	10	Fading Supports to Independence
3		EDIT (Convert Improper Fractions into Mixed Numbers)
	11	Introduce EDIT
	12	Model EDIT
	13	Collaborative Practice
	14	Peer Practice
	15	Fading Supports to Independence

Procedural Fidelity

The study's intervention consisted of 15 learning sessions. First, the investigator filled out the checklist to assess the fidelity of the intervention, while an independent mathematics teacher evaluated 30% of the learning sessions. Then, the investigator calculated the percentage of agreement (see below). First, the independent mathematics teachers examined five learning sessions of intervention sessions presented for the treatment group (5 out of 15 = 33% of the total sessions). After the groups were reversed, the independent mathematics teacher evaluated another five learning sessions of the control group that started receiving the intervention (i.e., 5 out of 15 = 33% of sessions).

To collect procedural fidelity data, the total number of agreements was divided by the total number of agreements and disagreements, and then, it was multiplied by 100% to obtain the percentage agreement. The mean fidelity score was 100%, suggesting a high level of procedural fidelity.

Data Analysis

For analyzing data in this study, the investigator used the following:

1- A two-by-two Repeated Measures Analysis of Variance (RM-ANOVA) was used to answer the first question to examine the effect of the intervention by evaluating the performance of two groups on the fraction tests across two points (pre-post-test). RM-ANOVA is a statistical tool used when researchers assess the subjects using the same measures more than two times (Dien & Santuzzi, 2005). To analyze the effect of experimental conditions, the investigator established $p < .05$ as a significance level to interpret the comparisons among the groups and partial eta-squared as an indicator of the effect size of group differences (Maggin et al., 2021).

2- RM-ANOVA was used to answer the second question, investigating the change in the control group's performance in fraction skills after receiving the intervention by comparing their performance across three points (a pre-post-test and a second post-test).

3- RM-ANOVA was used to answer the third question, examining the performance of the treatment group only in the fraction skills test across three points (a pre-post-test and a second post-test to measure maintenance of the fraction skills after one month of intervention).

4- Descriptive Statistics using SPSS was used to analyze students' responses to the social validity questionnaire. Additionally, the questionnaire included students' responses to an open-ended question. Open-ended responses enable researchers to explore subjects' experiences and perspectives on specific topics across various research fields (Feng & Behar-Horenstein, 2019). To analyze the open-ended question data, the investigator used the comments in a Word Document to code the data manually by grouping them logically into themes and patterns (Creswell & Poth, 2016). The investigator followed these steps:

   a. First, the investigator used the 'comment' function to code the data in the Microsoft Word program to code the data.
   b. Second, the investigator carefully read participants' responses to the open-ended question and coded the data based on their relation to the research question.
   c. Finally, the principal investigator analyzed the responses using "line-by-line coding" to identify the meaning units of the open-ended question and create labels for those meaning units (i.e., appreciation, expressing their overall experiences, views, opinions, or suggestions on the intervention, the strategies learned (FILMS/CUT/EDIT), and research setting).

CHAPTER 4: RESULTS

The study investigated the effect of using self-regulated strategy development (SRSD) in teaching fractions skills to eighth-grade students with average and low mathematics achievement in Oman. Accordingly**,** the study had four research questions.

First Research Question

What are the effects of Self-Regulation Strategy Development (FILMS, EDIT, and CUT) on the fraction performance of eighth-grade students with average and low mathematics achievement in Oman?

To answer the first research question, the investigator used a two-by-two repeated measures analysis of variance (RM-ANOVA) to examine the effect of the intervention (within-subject factor) on the fraction performance of eighth-grade students with average and low mathematics achievement at two points of the fraction assessment. Table 8 includes means, standard deviations, and sample sizes of student performance on the fraction test at pre-test and post-test, disaggregated by treatment condition.

Table 8

Means and Standard Deviations for each Group at Each Time Point of the Fraction Test

Fractions Test	**N**	***M***	***SD***
Pretest			
Treatment Group	30	2.03	1.69
Control Group	32	4.38	3.21
Total	62	3.24	2.83
Post-test1			
Treatment Group	30	13.47	4.31
Control Group	32	5.84	3.14
Total	62	9.53	5.35

Note. N= 62, *M*= Mean, *SD*= Std. Deviation

The repeated-measures ANOVA, indicated the main effect of time on fraction performance was statistically significant, F (1,60) = 161.542, p < .001. Using Cohen's (1988) benchmarks, this indicates a large effect (partial η^2 = .729). This effect was qualified by a significant time × group interaction effect, F(1,60) = 96.357, p < .001, partial η^2 = .616, indicating a large effect size.

Table 9

The Differences in Students' Performance on Fractions at Two Time Points

Group	(J) Times	(J) Times	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Treatment	2	1	11.433*	.729	<.001	9.975	12.892
Control	2	1	1.469*	.706	<.042	.056	2.881

Note. *Results of Pairwise Comparison Using the Bonferroni Test,* (1= pretest, 2= post-test1), p < .05

The results show significant differences in students' performance in solving fraction problems across two time points: the pretest and the post-test. Post-hoc comparisons using Bonferroni correction indicate that the students' scores on the post-test tended on average to outperform their scores on the pre-tests on solving Fraction problems (M= 11.43, SE=.73), p <.001. Similarly, the table shows a significant difference in the control group's scores on the post-test after receiving instruction (business as usual) on fraction skills compared to their scores on the pre-test (M = 1.47, SE=.71), p = .04. The results indicate an increasing trend in the performance of students from the pre-test to the post-test. The differences in students' performance on fraction skills in terms of the interaction between groups and times are demonstrated in Figure 4.

Figure 4

The differences in students' performance in fractions scores between-subjects factors

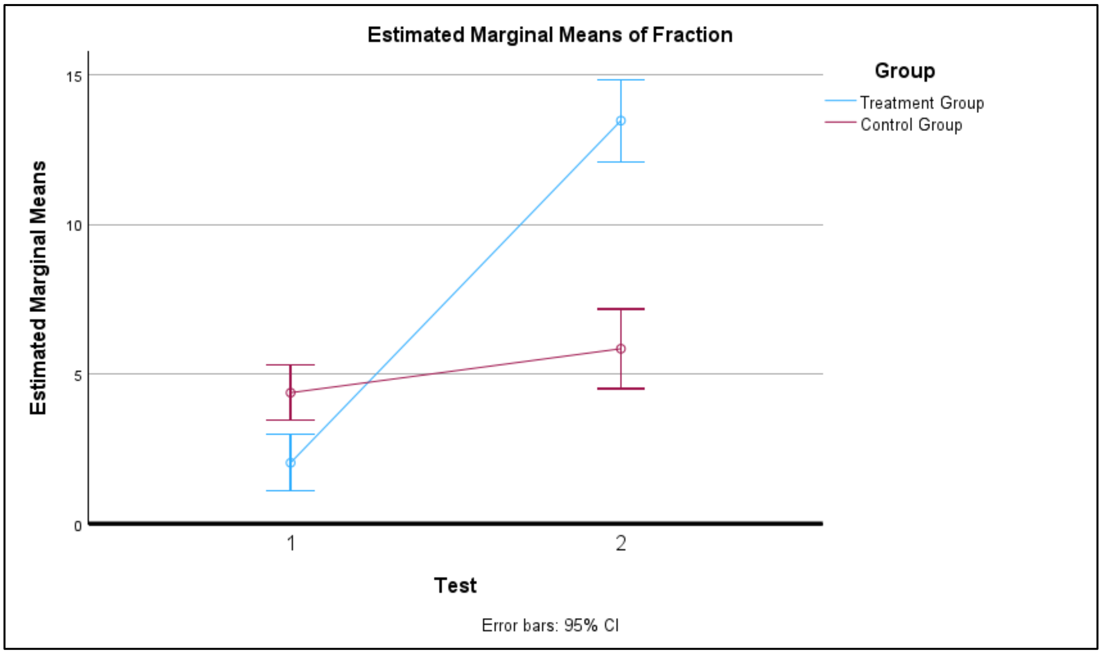


Figure 4 shows a statistically significant difference in Fraction scores concerning the interaction between the groups and times. In the pretest, students in the control group tended on average to outperform students in the treatment group in Fraction scores. After implementing the intervention for the treatment group, students' performance in the treatment group tended, on average, to outperform students in the control group on the post-test.

The next set of questions was designed to address (a) whether posttest fraction skills for students in the control condition would increase over 1 month if the intervention was provided to these students and (b) whether posttest fraction skills in the treatment condition would be maintained over a month once the intervention is ceased. The researcher was also interested in exploring whether mean changes from post-test to post-post-test differed between groups.

Second Research Question

Does the control group's performance in solving fraction problems change after receiving Self-Regulation Strategy Development?

To answer the second question, the investigator conducted RM-ANOVA (1 group [control], 3 time points). This analysis was used to compare the performance of the control group after receiving the intervention, when the groups were reversed. Table 10 shows all pairwise differences in students' performance in the control group on Fraction scores.

Table 10

The Differences in Students' Performance in the Control Group on Fractions at Three Time Points

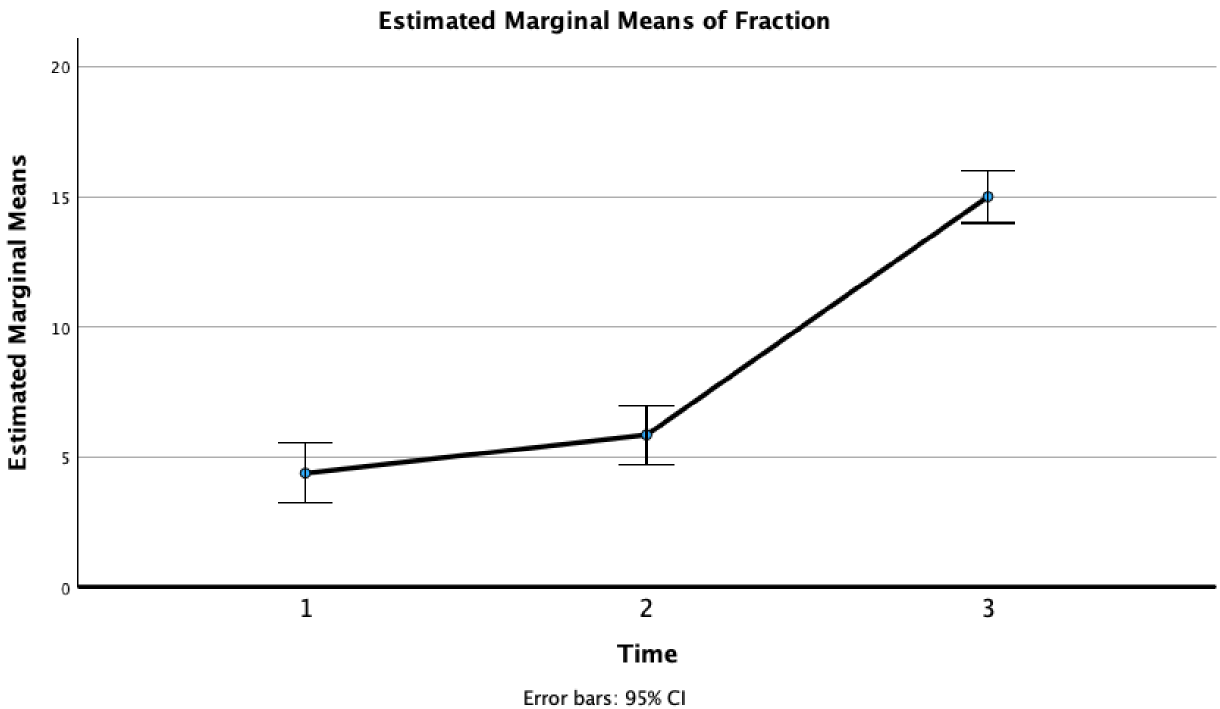
					95% Confidence Interval for Difference	
Control Group Times	**(J) Times**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**Lower Bound**	**Upper Bound**
2	1	1.469	.585	.053	-.013	2.950
3	1	10.625*	.647	<.001	8.987	12.263
	2	9.156*	.599	<.001	7.640	10.673

Note. Results of Pairwise Comparison Using the Bonferroni Test, (1= pretest, 2= post-test1, 3= post-test2), $p < .05$

The students in the control group received the intervention after taking the first post-test. The findings indicated statistically significant differences in students' performance in solving fraction problems after receiving the intervention, indicating that the intervention was effective. Figure 5 shows the differences in the control group's performance in solving fraction problems across three time points.

Figure 5

Control Group Performance on Fraction Test Across Three Time Points



Third Research Question

Was Self-Regulation Strategy Development effective at maintaining fraction skills 1 month after intervention?

To answer the second question, the investigator used a two-way repeated measures analysis of variance (RM-ANOVA) to compare the performance of the treatment group in the second and first time points to the third, respectively. Table 11 summarizes Bonferroni-adjusted paired t-tests. The table shows all pairwise differences in students' performance in the treatment group on Fraction scores after testing them three times.

Table 11

The Differences in Students' Performance in the Treatment Group on Fractions at Three Time Points

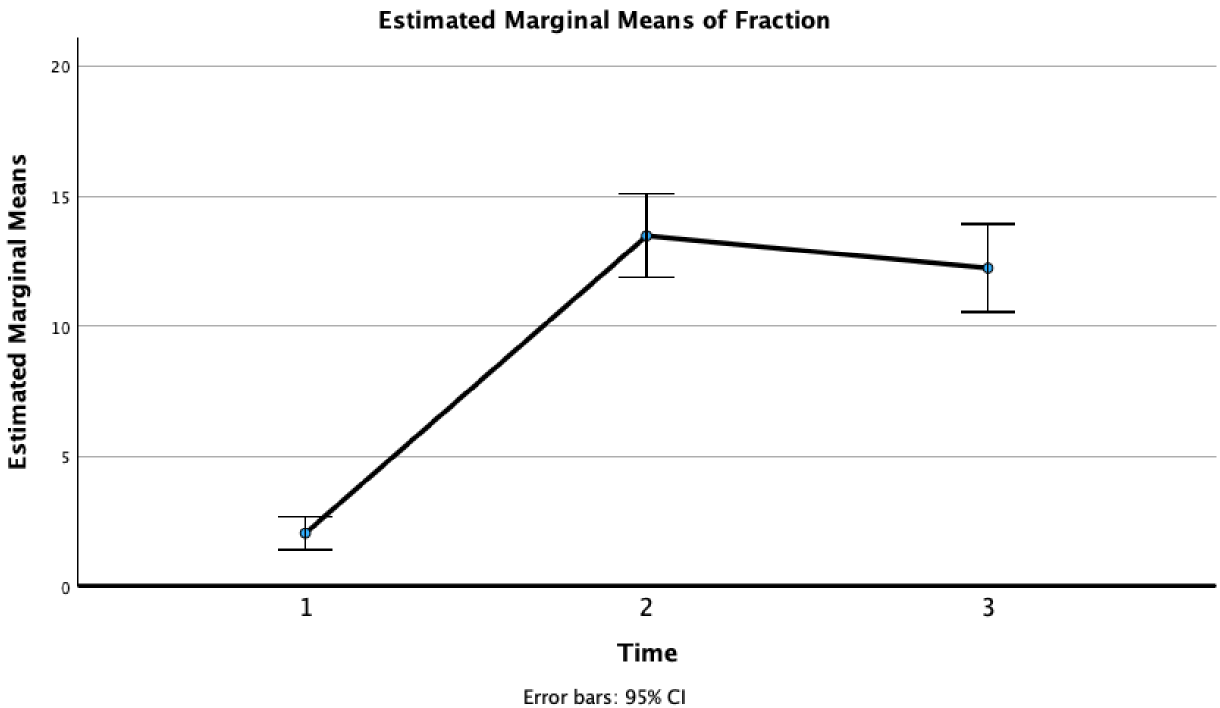
Treatment Group Times	(J) Times	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
2	1	11.433*	.729	<.001	9.637	13.230
3	1	10.200*	.763	<.001	8.320	12.080
	2	1.233	.617	.151	-2.753	.287

Note. Results of Pairwise Comparison Using the Bonferroni Test, (1= pretest, 2= post-test1, 3= post-test2), $p < .05$

The results show no statistically significant differences in students' performance between the post-test and the second post-test. Despite that, the mean differences indicate a slight regression in students' performance one month after receiving the intervention. Additionally, the results show statistically significant differences in students' performance in solving fraction problems after receiving the intervention, comparing the pretest and the second post-test. Post-hoc comparisons using Bonferroni indicate that the students' scores on the second post-test tended on average to outperform their performance on the pre-test on solving Fraction problems, indicating maintaining the fraction skills. Figure 6 demonstrates the performance og the treatment group on the fraction test across three time points.

Figure 6

Treatment Group Performance on Fraction Test Across Three Time Points



Fourth Research Question

What are the perspectives of eighth-grade students after receiving intervention on learning fractions using a self-regulation strategy with (FILMS, EDIT, and CUT) strategies?

To answer the research questions, the investigator provided descriptive statistics using SPSS to analyze students' responses to the social validity questionnaire. The results are summarized in Table 12.

Table 12

Descriptive Statistics for Students' Perspective of Using SRSD in Learning Fractions Skills

Dimension of Social Validity Scale	M (SD)	5	4	3	2	1	Missing
The Learning Setting							
Clarity of instruction for location and timing of learning sessions	4.95 (.22)	59 (95.2%)	3 (4.8%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Appropriateness of the learning environment	4.73 (.66)	49 (79%)	11 (17.7%)	1 (1.6%)	0 (0%)	1 (1.6%)	0 (0%)
The conflict between learning sessions and academic classes	5 (.00)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	62 (100%)	0 (0%)
Convenience of time duration for presenting the instructional sessions	4.58 (.69)	43 (69.4%)	12 (19.4%)	7 (11.3%)	0 (0%)	0(0%)	0 (0%)
Convenience of the timeline for completing tasks	4.47 (.74)	37 (59.7%)	18 (29%)	6 (9.7%)	1 (1.6%)	0(0%)	0 (0%)
The Learning Materials							
Clarity of the purpose of learning each strategy	4.89 (.41)	57 (91.9%)	3 (4.8%)	2 (3.2%)	0 (0%)	0(0%)	0 (0%)
Clarity of the learning content	4.79 (.45)	50 (80.6%)	11 (17.7%)	1 (1.6%)	0 (0%)	0(0%)	0 (0%)
Receiving the required learning materials to practice the strategy	4.76 (.53)	49 (79%)	12 (19.4%)	1 (1.6%)	0 (0%)	0(0%)	0 (0%)
Clarity of instructions on learning materials	4.81 (.74)	52 (83.9%)	8 (12.9%)	2 (3.2%)	0 (0%)	0(0%)	0 (0%)
The activities and tasks presented were practical	4.89 (.41)	57 (91.9)	3 (4.8%)	2 (3.2%)	0 (0%)	0(0%)	0 (0%)
The Strategies Learned							
FILMS and SRSD improved my skills in adding fractions	4.77 (.64)	52 (83.9%)	8 (12.9%)	1 (1.6%)	0 (0%)	1 (1.6%)	0 (0%)
FILMS and SRSD improved my skills in subtracting fractions	4.77 (.57)	51 (82.3%)	9 (14.5%)	1 (1.6%)	1 (1.6%)	0 (0%)	0 (0%)
CUT and SRSD improved my skill in simplifying fractions.	4.63 (.68)	46 (74.2%)	9 (14.5%)	7 (11.3%)	0 (0%)	0 (0%)	0 (0%)
EDIT and SRSD improved my skill in converting improper fractions into mixed numbers	4.77 (.53)	51 (82.3%)	8 (12.9%)	3 (4.8%)	0 (0%)	0 (0%)	0 (0%)

The intervention improved my performance in mathematics in the classroom.	4.94 (.31)	59 (95.2%)	2 (3.2%)	1 (1.6%)	0 (0%)	0 (0%)	0 (0%)

Note. *M* = means, *SD* = standard deviation, (Always=5, Often=4, Sometimes=3, Rarely=2, Never=1)

The overall mean participants' rating of the learning setting is 4.75 out of 5 which indicates that the student had an adequate learning setting regarding the learning environment, time setting, and the duration of learning sessions. In the study of the learning materials concerning the clarity of the learning purpose, the content presented, instructions, the learning materials, and the activities provided in each learning session, the overall mean rating was 4.83 out of 5.00. In the final dimension, the strategies learned in the intervention, the participant responses show that self-regulation strategies used in teaching fractions skills improved their performance in solving fractions problems with 4.78 as an overall mean rating out of 5.

On the open-ended question of the social validity questionnaire, almost one-third of participants expressed their appreciation by giving their thanks for receiving the intervention program. Twenty-three percent of the participants said they learned new learning techniques that helped them solve fraction problems. Almost half of the participants had positive views about how beneficial the intervention was for them; the percentage was 48% of all participants. Others saw the learning program as a wonderful experience that enriches their knowledge in mathematics, and they have fun at the same time.

Concerning the students' use of self-regulation strategies in learning fraction skills, 11% of participants revealed that the FILMS strategy in learning fraction computation was the easiest. Laila and Mary said that this strategy improved their performance in learning addition and subtraction with fractions. In contrast, 10% of participants found that the CUT strategy was the easiest and more fun compared to others. Rema and Jode found that they had difficulty learning the EDIT strategy.

However, some did not like the title of the research. In addition, the participants' responses show debate over time setting. Sara stated that “the time setting for learning sessions was convenient while Muna said that “they had to extend the class time to more than 40 minutes”. Lein and Julia revealed that “the school should provide regular learning sessions during the daytime to complete smoothly implementing the program”

CHAPTER 5: DISCUSSION

The study explored the effect of teaching self-regulated strategy development (SRSD) for fractions (FILMS; CUT and EDIT) for eighth-grade students with average and low mathematics achievement in Oman**.**

First, the study investigated the effects of SRSD fraction (FILMS, EDIT, and CUT) on the fraction performance of eighth-grade students with average and low mathematics achievement in Oman. The results show significant differences in students' performance in solving fraction problems across two time points: the pretest and the post-test. Students in the control group tended on average to outperform students in the treatment group in fraction scores. However, after implementing the intervention for the treatment group, students' performance in the treatment group tended, on average, to outperform students in the control group on the post-test. The study suggested that using SRSD fractions was responsible for these differences. The previous studies provided evidence that using SRSD in teaching fractions skills to students at risk or with mathematics disabilities enhanced their performance in solving fractions tasks (Losinski et al., 2019; 2021; Haker et al., 2019). According to Losinski et al. (2019), using SRSD fractions improves students' deficits and strengths through affective, behavioral, motivational, cognitive, or metacognitive strategies. Not to mention that using self-regulation strategies increases the motivational dynamics of learning (Trías et al., 2021), and motivation contributes to improving students' performance in mathematics (Shores & Shannon, 2007).

Second, the study explored whether there was a change in the control group's performance in solving fraction problems after receiving a Self-Regulation Strategy Development. The findings indicated significant differences in students' performance in solving fraction problems after receiving the intervention. The intervention contributed to the growth and improvement of the control group's performance in solving fraction problems, indicating the SRSD function is effective, and supporting the previous result.

Furthermore, the current study found a significant difference in fraction scores concerning the interaction between the groups and times. In the first post-test, after implementing the intervention for the treatment group, students in the treatment group outperformed students in the control group. In contrast, when groups were reversed, the students in the control group exhibited higher scores on the fraction test than the students in the treatment group on the second post-test. The studies attributed the fadeout of mathematics information among the students after stopping receiving the intervention to various reasons, such as differences in learning environments and pre-existing differences. The mechanisms of fadeout rely on learning environment differences (i.e., school, home) among students, and how these differences may influence maintaining the materials learned after completing the intervention by promoting them. In contrast, the pre-existing differences in cognitive abilities or considering the level of achievement before receiving the intervention play a substantial role in students' abilities to retain the learning content (Bailey et al., 2016; Bailey et al., 2020). In their study, Bailey et al. (2020) expanded on explaining the fadeout of intervention content by going beyond the differences in cognitive skills/ level of achievement to non-cognitive skills (i.e., motivation, self-regulation, and executive function), suggesting that these non-cognitive skills impact on the students’ memory retention of a content learned. Cirino et al. (2016) found that cognitive abilities (i.e., working memory, language, and spatial skills) besides many mathematical skills directly influence students' ability to acquire fraction skills and develop proportional reasoning. Similarly, Peng and Kievit (2020) outlined that cognitive skills (e.g., working memory, reasoning thinking, and executive function) predict academic abilities, including reading and mathematics, and vice versa. Accordingly, the current study suggested that students in the treatment group exhibited lower scores than students in the control group due to the fadeout of fraction skills learned. This fadeout is attributed to differences in learning environments, pre-existing differences in cognitive abilities, and the level of achievement.

Third, the study investigated whether SRSD is effective in helping students in the treatment group maintain fraction skills one month after intervention. The study findings demonstrated no significant differences in students' performance between the post-test and the second post-test, one month after receiving the intervention. Although, the mean differences indicate a slight regression in students' performance one month after receiving the intervention. The slight regression in students' scores supports the previous result of the fadeout of knowledge/skills over time and after stopping receiving the intervention or maintaining the activation of the fraction skills in learning situations.

Fourth, the current study investigated the perspectives of eighth-grade students with low and average mathematics achievement on the learning setting, the learning material, and the strategies learned after receiving the intervention on SRSD. The findings from the self-reported questionnaire show that the students were satisfied with the learning setting, learning material, and strategies learned. These results aligned with the previous studies that assessed the social validity of SRSD fractions with students who struggle in learning fraction skills; those studies found that students were satisfied with the intervention procedures **(**Losinski et al., 22019; Ennis & Losinski, 2019; Schwab et al., 2019).

The figures demonstrated that students had an appropriate learning setting concerning several issues, such as the learning environment and the duration of learning sessions. However, the students' perspectives on the SRSD fractions in the current study show a debate about the time setting. Sara stated that “the time setting for learning sessions was convenient,” while Muna said, “the time for some learning sessions should be extended to be more than 40 minutes”, indicating differences in the time required to learn or complete specific tasks. Additionally, some students suggested that the school has to provide a regular time and a classroom to present the intervention sessions smoothly during school hours. This statement is because the participants received the intervention sessions whenever they had activities classes on weekdays (i.e., Art, Music, Physical Education) or a free lesson (when some of their teachers were absent).

Regarding the learning materials, the data indicates that the learning materials were adequate and aligned with the learning purposes; the purpose of each strategy presented, the instructions, and the content were crystal clear. The study suggested that explicit instruction plays a role in providing the students with clear and specific information to acquire. According to the studies, presenting SRSD intervention relies on using explicit language which facilitates providing students with clear and concise instruction, enabling them to focus on crucial steps when learning academic skills such as writing (Harris et al., 2008; Limpo & Alves, 2013; Salas et al., 2023), reading (Mason et al., 2012), or fraction skills (Losinski et al., 22019; Ennis & Losinski, 2019).

Considering strategies learned, the outcomes outlined that students were satisfied with using self-regulation strategies in teaching fractions. Many students stated that “using SRSD improved their performance in solving fraction problems”. These findings were consistent with the study result of Losinski et al. (2019), where the students provided positive feedback on the SRSD Fractions intervention; one student revealed that calculation with fractions became much easier after using the strategies of SRSD. Another student from the study by Ennis and Losinski (2019) who was struggling to solve fraction problems, said, after completing the intervention on

SRSD, “Wow, this is easy, now”. Despite that, the results show a controversy in students' perspectives about which strategy was the easiest; some students agreed with the FILMS strategy, while others agreed with the CUT. Most students agreed that learning the EDIT strategy was challenging.

Generally, the students provided positive views on how beneficial the intervention was for them. Some students expressed appreciation for having the intervention and learning new learning techniques that helped them solve fraction problems. Other students described their experiences of receiving the SRSD intervention when learning fractions as having “enriched”, “fun”, and fantastic” experiences. This result is aligned with previous research using SRSD fractions, where students reported that the components of SRSD fractions (FILMS, CUT, EDIT) and related materials supported their memory and facilitated learning and solving fraction problems (Losinski et al., 2019; Ennis & Losinski, 2019**).** The current study suggests that using explicit instruction when presenting SRSD fractions regulates students' thinking and facilitates remembering the steps needed to solve fraction problems.

Limitations

The study has several limitations related to geographical location, culture, study implementation, assessments, and setting. The study has limitations due to geographical location and culture; the current study was conducted at a public school in the Al Batinah South governorate of Oman. Ethical guidelines differ from one country to another. Some aspects of the ethical guidelines presented by the IRB’s consent format are considered self-evident in Omani society. Hence, even when the children provided assents to participate in the study, some parents did not provide their consent because the format of parental consent approved by the IRB worried them. This situation causes a delay in collecting consent or having the required number of participants. The investigator makes more effort to reach out to parents to explain the IRB's guidelines.

The second limitation was related to study implementation. This study was conducted in the fall semester of 2024 at a public school in the Al Batinah South governorate of Oman. The Ministry of Education in Oman and the IRB provided approval to conduct the study during the fall semester. The fall semester is over by the end of January. However, some students drop out of school before finals to get ready. Not to mention that the students used to have several examinations (formative assessment, midterm, quizzes) during the semester, and all their limitations of time made us eliminate some of the screening measures such as (a) *Computation Problems with Whole Numbers* (i.e., multiplication + division) tests; (b) *Fraction Knowledge Assessment*; (c) and *Fraction Test Assessment*.

The current study also has limitations on math assessments. The investigator developed the pre-post-test *Fraction Skills Test*; however, there is no strong evidence of criterion validity for the researcher-created math assessment compared to a standardized measure of mathematics achievement. Additionally, there is a risk of "over-alignment" of mathematics measures for intervention content. The investigator did not evaluate the generalization of math skills learned via standardized measures of mathematics achievement.

The final limitation was related to the study settings. This limitation encourages some students to ask about the possibility of providing regular learning sessions during the school day to complete the smooth implementation of the program.

Implications for Practice

The outcomes show that using SRSD fractions in teaching facilitates mastery of fraction skills. However, several key points should be highlighted based on the current study results for future research and practice.

The total number of intervention sessions on teaching SRSD fractions to students in previous studies was 10 (Ennis & Losinski, 2019; Losinski et al., 2019) compared to the current study, which provided 15 intervention sessions. For future research, there is a need to conduct more studies using SRSD fractions by conducting a study that tests the dosage or number of sessions required per strategy to support student mastery (FILMS, EDIT, CUT).

In the current study, introducing the first lesson on using the FILM strategy required more than one learning session. Not to mention that some instructions related to the first strategy were overwhelming for students, confusing, and did not align with the limited time of the regular classroom setting. This crucial element from the current study may draw the researchers' attention to explore whether modifying the instructions and number of activities yields similar performance while reducing the number of instructional minutes. Additionally, there is a need for further research to investigate the effectiveness of providing students with homework rather than solving all fraction problems in the classroom, specifically after the third or fourth lessons, by activating a self-monitoring checklist. For future research, researchers need to measure changes in self-regulation pre- and post, and assess if the changes in self-regulation transfer to other subjects. Besides the intervention on SRSD fractions, future researchers may need to use several questionnaires to assess self-efficacy and motivation, considering how students' motivation may change over time. Finally, there is a need for further research to evaluate what pre-skills are most predictive of students' responses to SRSD.

For practice, teachers and administrators should consider several issues related to implementing the SRSD fraction based on the study outcomes. First, implementing SRSD fractions for students in regular classrooms requires teachers or administrators to be highly regulated and flexible in presenting the content of the learning sessions and managing class timing to complete the learning materials of each strategy within 40 minutes. Additionally, the teachers should be aware that the worksheet on the FILMS strategy includes 10 problems, requiring students to focus on solving fraction problems more than on fluency in multiplication. Hence, the study recommends that teachers provide students with extra material such as multiplication tables. Second, the study recommends that teachers activate homework after the third or fourth lesson (collaborative or peer practice) to increase students' engagement and manage the limitation of classroom timing. Third, the results from social validity indicate that students reported that the CUT strategy was easy to acquire compared to other learning strategies. Not to mention that the investigator did not spend more than 20 minutes accomplishing the last three learning sessions of the strategy. Accordingly, the current study recommends that teachers focus on teaching the FILMS strategy, increasing the dosage of learning sessions until mastery, and embedding the other two strategies (CUT and EDIT) with FILMS. The teachers need to distribute practice of math skills across time to limit the likelihood of forgetting or information fading. Finally, the study recommends that administrators provide future researchers with regular settings to facilitate the implementation of the SRSD fractions during the school day.

REFERENCES

Ader, E. (2019). What would you demand beyond mathematics? Teachers' promotion of students' self-regulated learning and metacognition. *ZDM*, *51*(4), 613-624. https://doi.org/10.1007/s11858-019-01054-8

Al Balushi, S. A. N. A., & Griffiths, D. A. V. I. D. (2013). The school education system in the Sultanate of Oman. In G., Donn & Y., Al Manthri (Eds.), *Education in the broader Middle East: Borrowing a baroque arsenal* (pp.107-126). Symposium Books Ltd.

Al-Issa, A. S. (2020). The language planning situation in the Sultanate of Oman. *Current Issues in Language Planning*, *21*(4), 347-414. https://doi.org/10.1080/14664208.2020.1764729

Al-Maamari, S. (2016). Education for connecting Omani students with other cultures in the world: The role of social studies. *International Review of Education*, *62*, 439-457. https://doi.org/10.1007/s11159-016-9577-2

Al-Mahrooqi, R., & Denman, C. (Eds.). (2018). *English education in Oman*. Springer Singapore.

Alnahdi, G. H. (2015). Single-subject designs in special education: advantages and limitations. *Journal of Research in Special Educational Needs*, *15*(4), 257-265. https://doi.org/10.1111/1471-3802.12039

Al-Salti, N. S., & Haydar, H. N. (2020). OMAN: Mathematics and mathematics education in Oman. B. R., Vogeli & M. E., El Tom (Eds.), *Mathematics and Its Teaching in the Muslim World* (pp. 183–202). World Scientific.

Al-Shabibi, A. & Alkharusi, H. (2018). Mathematical problem-solving and metacognitive skills of 5th grade students as a function of gender and level of academic achievement. *Cypriot Journal of Educational Sciences*, *13*(2), 149–159. https://doi.org/10.18844/cjes.v13i2.3306

Altun, S., & Erden, M. (2013). Self-regulation based learning strategies and self-efficacy perceptions as predictors of male and female students' mathematics achievement. *Procedia-Social and Behavioral Sciences*, *106*, 2354-2364. https://doi.org/10.1016/j.sbspro.2013.12.270

Archer, A. L., & Hughes, C. A. (2010). *Explicit instruction: Effective and efficient teaching*. Guilford Publications.

Baggetta, P., & Alexander, P. A. (2016). Conceptualization and operationalization of executive function. *Mind, Brain, and Education*, *10*(1), 10-33. https://doi.org/10.1111/mbe.12100

Bailey, D. H., Duncan, G. J., Cunha, F., Foorman, B. R., & Yeager, D. S. (2020). Persistence and fade-out of educational-intervention effects: Mechanisms and potential solutions. *Psychological Science in the Public Interest*, *21*(2), 55-97. https://doi.org/10.1177/1529100620915848

Bailey, D. H., Hoard, M. K., Nugent, L., & Geary, D. C. (2012). Competence with fractions predicts gains in mathematics achievement. *Journal of experimental child psychology*, *113*(3), 447-455. https://doi.org/10.1016/j.jecp.2012.06.004

Bailey, D. H., Nguyen, T., Jenkins, J. M., Domina, T., Clements, D. H., & Sarama, J. S. (2016). Fadeout in an early mathematics intervention: Constraining content or preexisting differences? *Developmental Psychology, 52*(9), 1457–1469. https://doi.org/10.1037/dev0000188

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, *52*(1), 1-26. https://doi.org/10.1146/annurev.psych.52.1.1

Baroody, A. J. (2003). The development of adaptive expertise and flexibility: The integration of conceptual and procedural knowledge. In A. J. Baroody & A. Dowker (Eds.), *The* *development of arithmetic concepts and skills: Constructive adaptive expertise* (pp. 1–33). Lawrence Erlbaum Associates. https://doi.org/10.4324/9781410607218

Begley, C. G., & Ellis, L. M. (2012). Raise standards for preclinical cancer research. *Nature*, *483*(7391), 531-533. https://doi.org/10.1038/483531a

Blum, W., & Niss, M. (1991). Applied mathematical problem solving, modeling, applications, and links to other subjects—State, trends, and issues in mathematics instruction. *Educational Studies in Mathematics*, *22*(1), 37-68. https://doi.org/10.1007/BF00302716

Burns, M. K., VanDerHeyden, A. M., & Jiban, C. L. (2006). Assessing the instructional level for mathematics: A comparison of methods. *School Psychology Review, 35*(3), 401-418. https://doi.org/10.1080/02796015.2006.12087975

Butterworth, B. (2005). The development of arithmetical abilities. *Journal of Child Psychology and Psychiatry*, *46*(1), 3-18. http://dx.doi.org/10.1111/j.1469-7610.2004.00374.x

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys*, *22*(1), 31-72. https://doi.org/10.1111/j.1467-6419.2007.00527.x

Canobi, K. H., Reeve, R. A., & Pattison, P. E. (2003). Patterns of knowledge in children's addition. *Developmental Psychology, 39*(3), 521–534. https://doi.org/10.1037/0012-1649.39.3.521

Caviola, S., Colling, L. J., Mammarella, I. C., & Szűcs, D. (2020). Predictors of mathematics in primary school: Magnitude comparison, verbal and spatial working memory measures. *Developmental Science*, *23*(6), e12957. https://doi.org/10.1111/desc.12957

Chambres, P., Izaute, M., & Marescaux, P. J. (Eds.). (2002). *Metacognition: Process, function, and use*. Springer Science & Business Media. https://doi.org/10.1007/978-1-4615-1099-4

Cirino, P. T., Tolar, T. D., Fuchs, L. S., & Huston-Warren, E. (2016). Cognitive and numerosity predictors of mathematical skills in middle school. *Journal of Experimental Child Psychology*, *145*, 95-119. https://doi.org/10.1016/j.jecp.2015.12.010

Claessens, A., & Engel, M. (2013). How important is where you start? Early mathematics knowledge and later school success. *Teachers College Record*, *115*(6), 1-29. https://psycnet.apa.org/record/2013-18273-005

Codding, R. S., Mercer, S., Connell, J., Fiorello, C., & Kleinert, W. (2016). Mapping the relationships among basic facts, concepts and application, and common core curriculum-based mathematics measures. *School Psychology Review*, *45*(1), 19-38.

Cohen, J. (1988). *Statistical power for the behavioral sciences* (2nd edition). Lawrence Earlbaum: Hillsdale, NJ.

Cook, B. G. (2014). A call for examining replication and bias in special education research. *Remedial and Special Education*, *35*(4), 233-246. https://doi.org/10.1177/0741932514528995

Cowan, N. (2008). What are the differences between long-term, short-term, and working memory?. *Progress in Brain Research*, *169*, 323-338. https://doi.org/10.1016/S0079-6123(07)00020-9

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage.

Cribbs, J., Huang, X., & Piatek-Jimenez, K. (2021). Relations of mathematics mindset, mathematics anxiety, mathematics identity, and mathematics self-efficacy to STEM career choice: A structural equation modeling approach. *School Science and Mathematics*, *121*(5), 275-287. https://doi.org/10.1111/ssm.12470

Crozier, W. R., & Perkins, P. (2002). Shyness as a factor when assessing children. *Educational Psychology in Practice*, *18*(3), 239-244.https://doi.org/10.1080/0266736022000010267

Daga, G. (2023). *[Re]presenting Oman: A discourse-historical analysis of Sultan Qaboos bin Said's (non-) alignments (1970–2020)* ([Doctoral dissertation, University of Trento]). IRIS - Institutional Research Information System. https://dx.doi.org/10.15168/11572_384029

Das, J. P., & Janzen, C. (2004). Learning math: Basic concepts, math difficulties, and suggestions for intervention. *Developmental Disabilities Bulletin, 32*(2), 191-205. https://eric.ed.gov/?id=EJ848198

Das, S., Das Mandal, S. K., & Basu, A. (2022). Classification of action verbs of Bloom's taxonomy cognitive domain: An empirical study. *Journal of Education, 202*(4), 554-566. https://doi.org/10.1177/00220574211002199

de Bruin, A. H., & van Gog, T. (2012). Improving self-monitoring and self-regulation: From cognitive psychology to the classroom. *Learning and Instruction*, *22*(4), 245-252. https://doi.org/10.1016/j.learninstruc.2012.01.003

DeWaelsche, S. A. (2015). Critical thinking, questioning and student engagement in Korean university English courses. *Linguistics and Education, 32*, 131-147. https://doi.org/10.1016/j.linged.2015.10.003

Dien, J., & Santuzzi, A. M. (2005). Application of repeated measures ANOVA to high-density ERP datasets: A review and tutorial. In T. C. Handy, (Ed.), *Event-related potentials: A methods handbook* (pp. 57-82). MIT Press.

Doabler, C. T., Baker, S. K., Kosty, D. B., Smolkowski, K., Clarke, B., Miller, S. J., & Fien, H. (2015). Examining the association between explicit mathematics instruction and student mathematics achievement. *The Elementary School Journal*, *115*(3), 303-333. https://doi.org/10.1086/679969

Doody, O., & Keenan, P. M. (2021). The reported effects of the COVID-19 pandemic on people with intellectual disability and their carers: a scoping review. *Annals of Medicine*, *53*(1), 786-804. https://doi.org/10.1080/07853890.2021.1922743

Drake, K., Belsky, J., & Fearon, R. M. (2014). From early attachment to engagement with learning in school: the role of self-regulation and persistence. *Developmental psychology*, *50*(5), 1350-1361. http://doi.org/10.1037/a0032779

Duckworth, A. L., & Yeager, D. S. (2015). Measurement matters: Assessing personal qualities other than cognitive ability for educational purposes. *Educational researcher*, *44*(4), 237-251. https://doi.org/10.3102/0013189X15584327

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, *14*(1), 4-58. https://doi.org/10.1177/1529100612453266

Efklides, A. (2011). Interactions of metacognition with motivation and affect in self-regulated learning: The MASRL model. *Educational Psychologist*, *46*(1), 6-25. https://doi.org/10.1080/00461520.2011.538645

Eisenberg, N., Fabes, R. A., Guthrie, I. K., & Reiser, M. (2000). Dispositional emotionality and regulation: Their role in predicting quality of social functioning. *Journal of Personality and Social Psychology*, *78*(1), 136–157. https://doi.org/10.1037/0022-3514.78.1.136

El-Zoghby, S. M., Soltan, E. M., & Salama, H. M. (2020). Impact of the COVID-19 pandemic on mental health and social support among adult Egyptians. *Journal of Community Health*, *45*, 689-695. https://doi.org/10.1007/s10900-020-00853-5

Ennis, R. P., & Jolivette, K. (2014). Using self-regulated strategy development for persuasive writing to increase the writing and self-efficacy skills of students with emotional and behavioral disorders in health class. *Behavioral Disorders*, *40*(1), 26-36. https://doi.org/10.17988/0198-7429-40.1.26

Ennis, R. P., & Losinski, M. (2019). Interventions to improve fraction skills for students with disabilities: A meta-analysis. *Exceptional Children*, *85*(3), 367-386. https://doi.org/10.1177/0014402918817504

Ennis, R. P., & Losinski, M. (2019). SRSD fractions: Helping students at risk for disabilities add/subtract fractions with unlike denominators. *Journal of Learning Disabilities*, *52*(5), 399-412. https://doi.org/10.1177/0022219419859509

Evans, N., & Levinson, S. C. (2009). The myth of language universals: Language diversity and its importance for cognitive science. *Behavioral and Brain Sciences*, *32*(5), 429-448. https://doi.org/10.1017/S0140525X0999094X

Feng, X., & Behar-Horenstein, L. (2019). Maximizing NVivo utilities to analyze open-ended responses. *The Qualitative Report*, *24*(3), 563-571.

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th edition). Sage.

Forsyth, S. R., & Powell, S. R. (2017). Differences in the mathematics-vocabulary knowledge of fifth-grade students with and without learning difficulties. *Learning Disabilities Research & Practice*, *32*(4), 231-245. https://doi.org/10.1111/ldrp.12144

Francis, G. (2012). The psychology of replication and replication in psychology. *Perspectives on Psychological Science, 7*(6), 585-594. https://doi.org/10.1177/1745691612459520

Fuchs, L. S., Malone, A. S., Schumacher, R. F., Namkung, J., & Wang, A. (2017). Fraction intervention for students with mathematics difficulties: Lessons learned from five randomized controlled trials. *Journal of Learning Disabilities, 50*(6), 631-639. https://doi.org/10.1177/0022219416677249

Fuchs, L.S., Newman-Gonchar, R., Schumacher, R., Dougherty, B., Bucka, N., Karp, K.S., Woodward, J., Clarke, B., Jordan, N. C., Gersten, R., Jayanthi, M., Keating, B., and Morgan, S. (2021). *Assisting students struggling with mathematics: Intervention in the elementary grades* (WWC 2021006). National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education.

Gathercole, S. E., & Pickering, S. J. (2000). Working memory deficits in children with low achievements in the national curriculum at 7 years of age. *British Journal of Educational Psychology, 70*(2), 177-194. https://doi.org/10.1348/000709900158047

Gersten, R., Chard, D. J., Jayanthi, M., Baker, S. K., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research, 79*(3), 1202-1242. https://doi.org/10.3102/0034654309334431

Gibbs, A. S., Hinton, V. M., & Flores, M. M. (2018). A case study using CRA to teach students with disabilities to count using flexible numbers: Applying skip counting to multiplication. *Preventing School Failure: Alternative Education for Children and Youth, 62*(1), 49-57. https://doi.org/10.1080/1045988X.2017.1342218

Graham, S., & Harris, K. R. (2018). An examination of the design principles underlying a self-regulated strategy development study. *Journal of Writing Research*, *10*(2), 139-187. https://doi.org/10.17239/jowr-2018.10.02.02

Graham, S., McKeown, D., Kiuhara, S., & Harris, K. R. (2012). A meta-analysis of writing instruction for students in the elementary grades. *Journal of educational psychology*, *104*(4), 879-896. https://doi.org/10.1037/a0029185

Hacker, D. J., Kiuhara, S. A., & Levin, J. R. (2019). A metacognitive intervention for teaching fractions to students with or at-risk for learning disabilities in mathematics. *ZDM*, *51*(4), 601-612. https://doi.org/10.1007/s11858-019-01040-0

Hacker, Douglas J ; Dunlosky, John ; Graesser, Arthur C. (2009). Self-Regulation: Where Metacognition and Motivation Intersect. In *Handbook of Metacognition in Education* (pp. 311-328). Routledge.

Handley, M. A., Lyles, C. R., McCulloch, C., & Cattamanchi, A. (2018). Selecting and improving quasi-experimental designs in effectiveness and implementation research. *Annual Review of Public Health*, *39*, 5-25. https://doi.org/10.1146/annurev-publhealth-040617-014128

Harris, K. R. (2024). The self-regulated strategy development instructional model: Efficacious theoretical integration, scaling up, challenges, and future research. *Educational Psychology Review*, *36*(4), 104. https://doi.org/10.1007/s10648-024-09921-x

Harris, K. R., & Graham, S. (1999). Programmatic intervention research: Illustrations from the evolution of self-regulated strategy development. *Learning Disability Quarterly*, *22*(4), 251-262. https://doi.org/10.2307/1511259

Harris, K. R., & Graham, S. (2009). Self-regulated strategy development in writing: Premises, evolution, and the future. *British Journal of Educational Psychology*, *2*(6), 113-135. https://doi.org/10.1348/978185409X422542

Harris, K. R., Graham, S., Mason, L. H., & Friedlander, B. (2008). *Powerful writing strategies for all students*. Brookes.

Hassinger-Das, B., Jordan, N. C., Glutting, J., Irwin, C., & Dyson, N. (2014). Domain-general mediators of the relation between kindergarten number sense and first-grade mathematics achievement. *Journal of Experimental Child Psychology*, *118*, 78-92. https://doi.org/10.1016/j.jecp.2013.09.008

Heemsoth, T., & Heinze, A. (2014). The impact of incorrect examples on learning fractions: A field experiment with 6th grade students. *Instructional Science, 42*(4), 639-657. https://doi.org/10.1007/s11251-013-9302-5

Hiebert, J., & Lefevre, P. (2013). Conceptual and procedural knowledge in mathematics: An introductory analysis. In J. Hiebert (Ed.), *Conceptual and procedural knowledge: The case of mathematics* (pp. 1–27). Lawrence Erlbaum Associates.

Hofmann, W., Friese, M., Schmeichel, B. J., & Baddeley, A. D. (2011). Working memory and self-regulation. In K. D. Vohs & R. F. Baumeister (Eds.), *Handbook of self-regulation: Research, theory, and applications* (2nd ed., pp. 204-225). Guilford Press.

Hott, B. L., Brigham, F. J., & Peltier, C. (Eds.). (2021). *Research Methods in Special Education*. Slack Incorporated.

Howard, S. J., Neilsen-Hewett, C., de Rosnay, M., Vasseleu, E., & Melhuish, E. (2019). Evaluating the viability of a structured observational approach to assessing early self-regulation. *Early Childhood Research Quarterly*, *48*, 186-197. https://doi.org/10.1016/j.ecresq.2019.03.003

Hughes, E. M., Powell, S. R., & Stevens, E. A. (2016). Supporting clear and concise mathematics language: Instead of that, say this. *Teaching Exceptional Children*, *49*(1), 7-17. https://doi.org/10.1177/004005991665490

Hughes, J. N., Luo, W., Kwok, O. M., & Loyd, L. K. (2008). Teacher-student support, effortful engagement, and achievement: A 3-year longitudinal study. *Journal of Educational Psychology*, *100*(1), 1-14. http://dx.doi.org/10.1037/0022-0663.100.1.1

Ilkowska, M., & Engle, R. W. (2010). Working memory capacity and self-regulation. In R. H. Hoyle (Ed.), *Handbook of personality and self-regulation*, (pp. 263-290). Wiley-Blackwell.

Institute of Educational Sciences, National Center for Education Statistics. (2023). *Explore results for the 2022 NAEP mathematics assessment*. https://nces.ed.gov/nationsreportcard/mathematics/

Issan, S., & Gomaa, N. (2010). Post basic education reforms in Oman: A case study. *Literacy Information and Computer Education Journal*, *1*(1), 19-27. https://doi.org/10.20533/licej.2040.2589.2010.0004

Jasny, B. R., Chin, G., Chong, L., & Vignieri, S. (2011). Again, and again, and again…. *Science*, *334*(6060), 1225-1225. https://doi.org/10.1126/science.334.6060.1225

Jefferson, A. L., Paul, R. H., Ozonoff, A. L., & Cohen, R. A. (2006). Evaluating elements of executive functioning as predictors of instrumental activities of daily living (IADLs). *Archives of Clinical Neuropsychology*, *21*(4), 311-320. https://doi.org/10.1016/j.acn.2006.03.007

Johnson, E. S., Clohessy, A. B., & Chakravarthy, P. (2021). A self-regulated learner framework for students with learning disabilities and math anxiety. *Intervention in School and Clinic*, *56*(3), 163-171. https://doi.org/10.1177/1053451220942203

Jones, J. (2012). *Oman, culture and diplomacy*. Edinburgh University Press. https://doi.org/10.1515/9780748674619

Jones, K. S., Derby, P. L., & Schmidlin, E. A. (2010). An investigation of the prevalence of replication research in human factors. *Human Factors*, *52*(5), 586-595. https://doi.org/10.1177/0018720810384394

Jordan, N. C., Resnick, I., Rodrigues, J., Hansen, N., & Dyson, N. (2017). Delaware longitudinal study of fraction learning: Implications for helping children with mathematics difficulties. *Journal of Learning Disabilities*, *50*(6), 621-630. https://doi.org/10.1177/0022219416662033

Jozwik, S. L., Cuenca-Carlino, Y., Mustian, A. L., & Douglas, K. H. (2019). Evaluating a self-regulated strategy development reading-comprehension intervention for emerging bilingual students with learning disabilities. *Preventing School Failure: Alternative Education for Children and Youth*, *63*(2), 121-132. https://doi.org/10.1080/1045988X.2018.1523126

Katou, A. A., Budhwar, P. S., Woldu, H., & Basit Al-Hamadi, A. (2010). Influence of ethical beliefs, national culture and institutions on preferences for HRM in Oman. *Personnel Review*, *39*(6), 728-745. https://doi.org/10.1108/00483481011075585

Kim, M. A., Yi, J., Jung, S. M., Hwang, S., & Sung, J. (2021). A qualitative study on parents' concerns about adult children with intellectual disabilities amid the COVID-19 pandemic in South Korea. *Journal of Applied Research in Intellectual Disabilities*, *34*(4), 1145–1155. https://doi.org/10.1111/jar.12875

Kitsantas, A., & Zimmerman, B. J. (2006). Enhancing self-regulation of practice: The influence of graphing and self-evaluative standards. *Metacognition and Learning*, *1*, 201-212. https://doi.org/10.1007/s11409-006-9000-7

Klesczewski, J., Brandenburg, J., Fischbach, A., Grube, D., Hasselhorn, M., & Büttner, G. (2015). Working memory functioning in children with poor mathematical skills. *Zeitschrift Für Psychologie*, *223*(2), 83-92. https://doi.org/10.1027/2151-2604/a000206

Kourtidis, J. (2019). *The effect of metacognition instruction on student performance* [Doctoral dissertation, University of St. Francis]. Francis ProQuest Dissertations Publishing.

Kramsch, C. (2014). Language and culture. *AILA review*, *27*(1), 30-55. https://doi.org/10.1075/aila.27.02kra

Lenz, K., Dreher, A., Holzäpfel, L., & Wittmann, G. (2020). Are conceptual knowledge and procedural knowledge empirically separable? The case of fractions. *British Journal of Educational Psychology*, *90*(3), 809-829. https://doi.org/10.1111/bjep.12333

Lewis, K., & Kuhfeld, M. (2021). Learning during COVID-19: An update on student achievement and growth at the start of the 2021-22 school year. Brief. *Center for School and Student Progress at NWEA*. https://eric.ed.gov/?id=ED627550

Limpo, T., & Alves, R. A. (2013). Teaching planning or sentence-combining strategies: Effective SRSD interventions at different levels of written composition. *Contemporary Educational Psychology*, *38*(4), 328-341. https://doi.org/10.1016/j.cedpsych.2013.07.004

Long, H. M., Bouck, E. C., & Jakubow, L. N. (2021). Explicit instruction in mathematics: Considerations for virtual learning. *Journal of Special Education Technology*, *36*(2), 67-76. https://doi.org/10.1177/0162643421994099

Losinski, M., Cuenca-Carlino, Y., Zablocki, M., & Teagarden, J. (2014). Examining the efficacy of self-regulated strategy development for students with emotional or behavioral disorders: A meta-analysis. *Behavioral Disorders*, *40*(1), 52-67. https://doi.org/10.17988/0198-7429-40.1.52

Losinski, M., Ennis, R. P., & Shaw, A. (2021). Using SRSD to improve the fraction computations of students with and at-risk for EBD. *Behavioral Disorders*, *46*(2), 108-119. https://doi.org/10.1177/0198742920912737

Losinski, M., Ennis, R. P., Sanders, S., & Wiseman, N. (2019). An investigation of SRSD to teach fractions to students with disabilities. *Exceptional Children*, *85*(3), 291-308. https://doi.org/10.1177/0014402918813980

Lucangeli, D., Fastame, M. C., Pedron, M., Porru, A., Duca, V., Hitchcott, P. K., & Penna, M. P. (2019). Metacognition and errors: The impact of self-regulatory training in children with specific learning disabilities. *ZDM*, *51*, 577-585. https://doi.org/10.1007/s11858-019-01044-w

Macgowan, M. J., & Wong, S. E. (2014). Single-case designs in group work: Past applications, future directions. *Group Dynamics: Theory, Research, and Practice, 18*(2), 138–158. https://doi.org/10.1037/gdn0000003

Maggin, D. M., Barton, E., Reichow, B., Lane, K., & Shogren, K. A. (2021). Commentary on the What Works Clearinghouse Standards and Procedures Handbook (v. 4.1) for the review of single-case research. *Remedial and Special Education*, *43*(6), 421-433. https://doi.org/10.1177/07419325211051317

Mägi, K., Männamaa, M., & Kikas, E. (2016). Profiles of self-regulation in elementary grades: Relations to math and reading skills. *Learning and Individual Differences*, *51*, 37-48. https://doi.org/10.1016/j.lindif.2016.08.028

Makel, M. C., & Plucker, J. A. (2014). Facts are more important than novelty: Replication in the education sciences. *Educational Researcher*, *43*(6), 304-316. https://doi.org/10.3102/0013189X14545513

Makel, M. C., Plucker, J. A., Freeman, J., Lombardi, A., Simonsen, B., & Coyne, M. (2016). Replication of special education research: Necessary but far too rare. *Remedial and Special Education*, *37*(4), 205-212. https://doi.org/10.1177/0741932516646083

Mason, L. H., Reid, R., & Hagaman, J. L. (2012). *Building comprehension in adolescents: Powerful strategies for improving reading and writing in content areas*. Brookes.

McCoy, D. C. (2019). Measuring young children's executive function and self-regulation in classrooms and other real-world settings. *Clinical child and family psychology review*, *22*, 63-74. https://doi.org/10.1007/s10567-019-00285-1

Merkley, R., & Ansari, D. (2016). Why numerical symbols count in the development of mathematical skills: Evidence from brain and behavior. *Current Opinion in Behavioral Sciences*, *10*, 14-20. https://doi.org/10.1016/j.cobeha.2016.04.006

Mevarech, Z. R., & Kramarski, B. (1997). IMPROVE: A multidimensional method for teaching mathematics in heterogeneous classrooms. *American Educational Research Journal*, *34*(2), 365-394. https://doi.org/10.3102/00028312034002365

Miller-Cotto, D., & Byrnes, J. P. (2020). What's the best way to characterize the relationship between working memory and achievement?: An initial examination of competing theories. *Journal of Educational Psychology, 112*(5), 1074-1084. https://doi.org/10.1037/edu0000395

Misquitta, R. (2011). A review of the literature: Fraction instruction for struggling learners in mathematics. *Learning Disabilities Research & Practice*, *26*(2), 109-119. https://doi.org/10.1111/j.1540-5826.2011.00330.x

Montague, M. (2007). Self-regulation and mathematics instruction. *Learning Disabilities Research & Practice*, *22*(1), 75-83. https://doi.org/10.1111/j.1540-5826.2007.00232.x

Moore, A. M., & Geary, D. C. (2016). Kindergartners' fluent processing of symbolic numerical magnitude is predicted by their cardinal knowledge and implicit understanding of arithmetic 2 years earlier. *Journal of Experimental Child Psychology*, *150*, 31-47. https://doi.org/10.1016/j.jecp.2016.05.003

Morano, S., Flores, M. M., Hinton, V., & Meyer, J. (2020). A comparison of concrete-representational-abstract and concrete-representational-abstract-integrated fraction interventions for students with disabilities. *Exceptionality*, *28*(2), 77-91. https://doi.org/10.1080/09362835.2020.1727328

Morgan, P. L., Farkas, G., & Wu, Q. (2009). Five-year growth trajectories of kindergarten children with learning difficulties in mathematics. *Journal of Learning Disabilities*, *42*(4), 306-321. https://doi.org/10.1177/0022219408331037

National Institute of Corrections [NIC]. (2023). *Evidence-based Practices (EBP)*. https://nicic.gov/resources/resources-topics-and-roles/topics/evidence-based-practices-ebp

Nelson, G., Hughes Pfannenstiel, K., & Zumeta Edmonds, R. (2020). Examining the alignment of mathematics instructional practices and mathematics vocabulary between core and intervention materials. *Learning Disabilities Research & Practice, 35*(1), 14-24. https://doi.org/10.1111/ldrp.12210

Neuman, Y., & Schwarz, B. (1998). Is self-explanation while solving problems helpful? The case of analogical problem-solving. *British Journal of Educational Psychology*, *68*(1), 15-24. https://doi.org/10.1111/j.2044-8279.1998.tb01271.x

Odom, S. L. (2021). Education of students with disabilities, science, and randomized controlled trials. *Research and Practice for Persons with Severe Disabilities*, *46*(3), 132-145. https://doi.org/10.1177/15407969211032341

Oppong, E., Shore, B. M., & Muis, K. R. (2019). Clarifying the connections among giftedness, metacognition, self-regulation, and self-regulated learning: Implications for theory and practice. *Gifted Child Quarterly, 63*(2), 102-119. https://doi.org/10.1177/0016986218814008

Otto, B., & Kistner, S. (2017). Is there a Matthew effect in self-regulated learning and mathematical strategy application?-Assessing the effects of a training program with standardized learning diaries. *Learning and Individual Differences, 55*, 75-86.

Passolunghi, M. C., Caviola, S., De Agostini, R., Perin, C., & Mammarella, I. C. (2016). Mathematics anxiety, working memory, and mathematics performance in secondary-school children. *Frontiers in Psychology*, *7*, 42. https://doi.org/10.3389/fpsyg.2016.00042

Peng, P., & Kievit, R. A. (2020). The development of academic achievement and cognitive abilities: A bidirectional perspective. *Child Development Perspectives, 14*(1), 15-20. https://doi.org/10.1111/cdep.12352

Peng, P., & Lin, X. (2019). The relation between mathematics vocabulary and mathematics performance among fourth graders. *Learning and Individual Differences*, *69*, 11-21. https://doi.org/10.1016/j.lindif.2018.11.006

Peng, P., Lin, X., Ünal, Z. E., Lee, K., Namkung, J., Chow, J., & Sales, A. (2020). Examining the mutual relations between language and mathematics: A meta-analysis. *Psychological Bulletin, 146*(7), 595–634. https://doi.org/10.1037/bul0000231

Peng, P., Namkung, J., Barnes, M., & Sun, C. (2016). A meta-analysis of mathematics and working memory: Moderating effects of working memory domain, type of mathematics skill, and sample characteristics. *Journal of Educational Psychology, 108*(4), 455–473. https://doi.org/10.1037/edu0000079

Peng, P., Wang, T., Wang, C., & Lin, X. (2019). A meta-analysis on the relation between fluid intelligence and reading/mathematics: Effects of tasks, age, and social economics status. *Psychological Bulletin, 145*(2), 189–236. https://doi.org/10.1037/bul0000182

Perels, F., Dignath, C., & Schmitz, B. (2009). Is it possible to improve mathematical achievement by means of self-regulation strategies? Evaluation of an intervention in regular math classes. *European Journal of Psychology of Education*, *24*, 17-31. https://doi.org/10.1007/BF03173472

Petry, N. M., Weinstock, J., & Alessi, S. M. (2011). A randomized trial of contingency management delivered in the context of group counseling. *Journal of Consulting and Clinical Psychology, 79*(5), 686–696. https://doi.org/10.1037/a0024813

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, M. Zeidner & P. R. Pintrich (Eds.), *Handbook of Self-Regulation* (pp. 451-502). Academic Press.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*(1), 33–40. https://doi.org/10.1037/0022-0663.82.1.33

Poncy, B. C., & Dun, G. J. (2017). *MIND: Resources for early numeracy & computational skills*. https://brianponcy.wixsite.com/mind

Purpura, D. J., Logan, J. A., Hassinger-Das, B., & Napoli, A. R. (2017). Why do early mathematics skills predict later reading? The role of mathematical language. *Developmental Psychology*, *53*(9), 1633-1642. https://doi.org/10.1037/dev0000375

Resnick, I., Jordan, N. C., Hansen, N., Rajan, V., Rodrigues, J., Siegler, R. S., & Fuchs, L. S. (2016). Developmental growth trajectories in understanding of fraction magnitude from fourth through sixth grade. *Developmental Psychology*, *52,* 746–757. http://dx.doi.org/10.1037/dev0000102

Riccomini, P. J., Smith, G. W., Hughes, E. M., & Fries, K. M. (2015). The language of mathematics: The importance of teaching and learning mathematical vocabulary. *Reading & Writing Quarterly*, *31*(3), 235-252. https://doi.org/10.1080/10573569.2015.1030995

Rittle-Johnson, B., & Star, J. R. (2007). Does comparing solution methods facilitate conceptual and procedural knowledge? An experimental study on learning to solve equations. *Journal of Educational Psychology*, *99*(3), 561–574. https://doi.org/10.1037/0022-0663.99.3.561

Rizta, A., Zulkardi, Z., & Hartono, Y. (2013). Pengembangan soal penalaran model TIMSS matematika SMP. *Jurnal Penelitian dan Evaluasi Pendidikan*, *17*(2), 230-240.

Roesslein, R. I., & Codding, R. S. (2019). Fraction interventions for struggling elementary math learners: A review of the literature. *Psychology in the Schools*, *56*(3), 413-432. https://doi.org/10.1002/pits.22196

Sáenz, C. (2009). The role of contextual, conceptual and procedural knowledge in activating mathematical competencies (PISA). *Educational Studies in Mathematics*, *71*(2), 123-143. https://doi.org/10.1007/s10649-008-9167-8

Salas, N., Pascual, M., Birello, M., & Cross, A. (2023). Embedding explicit linguistic instruction in an SRSD writing intervention. *Written Communication*, *40*(3), 857-891. https://doi.org/10.1177/07410883231169516

Sanders, S., & Garwood, J. D. (2022). Assessment of effective strategy instruction and reading comprehension. *Preventing School Failure: Alternative Education for Children and Youth*, *66*(4), 320-326. https://doi.org/10.1080/1045988X.2022.2076641

Sanders, S., Hart Rollins, L., Michael, E., & Jolivette, K. (2022). "TRAP is legit!" using self-regulated strategy development to teach reading comprehension in a residential treatment facility. *Preventing School Failure: Alternative Education for Children and Youth*, *66*(1), 89-98. https://doi.org/10.1080/1045988X.2021.1972921

Sanders, S., Losinski, M., Parks Ennis, R., White, W., Teagarden, J., & Lane, J. (2019). A meta-analysis of self-regulated strategy development reading interventions to improve the reading comprehension of students with disabilities. *Reading & Writing Quarterly*, *35*(4), 339-353. https://doi.org/10.1080/10573569.2018.1545616

Schmitt, N. (2014). Size and depth of vocabulary knowledge: What the research shows. *Language Learning*, *64*(4), 913-951. https://doi.org/10.1111/lang.12077

Schneider, M., & Stern, E. (2010). The developmental relations between conceptual and procedural knowledge: A multimethod approach. *Developmental Psychology, 46*(1), 178–192. https://doi.org/10.1037/a0016701

Schneider, M., Rittle-Johnson, B., & Star, J. R. (2011). Relations among conceptual knowledge, procedural knowledge, and procedural flexibility in two samples differing in prior knowledge. *Developmental Psychology, 47*(6), 1525–1538. https://doi.org/10.1037/a0024997

Schult, J., Mahler, N., Fauth, B., & Lindner, M. A. (2022). Did students learn less during the COVID-19 pandemic? Reading and mathematics competencies before and after the first pandemic wave. *School Effectiveness and School Improvement*, *33*(4), 544-563.

Schunk, D. H., & Zimmerman, B. J. (2012). Self-regulation and learning. In W. M. Reynolds, G. E. Miller& I. B. Weiner (Eds.), *Handbook of psychology* (2nd ed., Vol. 7, pp. 45-68). Wiley.

Schunk, D. H., & Zimmerman, B. J. (Eds.). (2012). *Motivation and self-regulated learning: Theory, research, and applications*. Routledge.

Schwab, J. R., Houchins, D. E., Peng, P., McKeown, D., Varjas, K., & Emerson, J. (2019). The Effects of a Multi-Component Intervention to Increase Math Performance for Students with EBD in Alternative Educational Settings. *International Journal of Special Education*, *34*(1), 226-244. https://eric.ed.gov/?id=EJ1237166

Shahbaba, B., & Shahbaba, B. (2012). Analysis of variance (ANOVA). *Biostatistics with R: An Introduction to Statistics Through Biological Data*, 221-234. https://doi.org/10.1007/978-1-4614-1302-8_9

Shin, M., & Bryant, D. P. (2015). Fraction interventions for students struggling to learn mathematics: A research synthesis. *Remedial and Special Education*, *36*(6), 374-387. https://doi.org/10.1177/0741932515572910

Shipman, J. E., Swanquist, Q. T., & Whited, R. L. (2017). Propensity score matching in accounting research. *The Accounting Review*, *92*(1), 213-244. https://doi.org/10.2308/accr-51449

Siegler, R. S., Duncan, G. J., Davis-Kean, P. E., Duckworth, K., Claessens, A., Engel, M., ... & Chen, M. (2012). Early predictors of high school mathematics achievement. *Psychological Science*, *23*(7), 691-697. https://doi.org/10.1177/0956797612440101

Siegler, R., Carpenter, T., Fennell, F., Geary, D., Lewis, J., Okamoto, Y., Thompson, L., & Wray, J. (2010). *Developing effective fractions instruction for kindergarten through 8th grade: A practice guide* (NCEE #2010-4039). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Smith-Donald, R., Raver, C. C., Hayes, T., & Richardson, B. (2007). Preliminary construct and concurrent validity of the Preschool Self-regulation Assessment (PSRA) for field-based research. *Early Childhood Research Quarterly*, *22*(2), 173-187. https://doi.org/10.1016/j.ecresq.2007.01.002

Stafylidou, S., & Vosniadou, S. (2004). The development of students' understanding of the numerical value of fractions. *Learning and Instruction*, *14*(5), 503-518. https://doi.org/10.1016/j.learninstruc.2004.06.015

Storch, S. A., & Whitehurst, G. J. (2002). Oral language and code-related precursors to reading: evidence from a longitudinal structural model. *Developmental Psychology*, *38*(6), 934-947. https://doi.org/10.1037/0012-1649.38.6.934

Ten Braak, D., Lenes, R., Purpura, D. J., Schmitt, S. A., & Størksen, I. (2022). Why do early mathematics skills predict later mathematics and reading achievement? The role of executive function. *Journal of Experimental Child Psychology*, *214*, 105306. https://doi.org/10.1016/j.jecp.2021.105306

Toering, T., Elferink-Gemser, M. T., Jonker, L., van Heuvelen, M. J., & Visscher, C. (2012). Measuring self-regulation in a learning context: Reliability and validity of the Self-Regulation of Learning Self-Report Scale (SRL-SRS). *International Journal of Sport and Exercise Psychology*, *10*(1), 24-38. https://doi.org/10.1007/s10567-019-00285

Torbeyns, J., Schneider, M., Xin, Z., & Siegler, R. S. (2015). Bridging the gap: Fraction understanding is central to mathematics achievement in students from three different continents. *Learning and Instruction*, *37*, 5-13. https://doi.org/10.1016/j.learninstruc.2014.03.002

Trías, D., Mels, C., & Martínez, J. A. H. (2021). Teaching to self-regulate in mathematics: A quasi-experimental study with low-achieving elementary school students. *REDIE: Revista Electrónica de Investigación Educativa*, (23), 5, 1-13. https://doi.org/10.24320/redie.2021.23.e02.2945

Troyer, M. (2022). The gold standard for whom? Schools' experiences participating in a randomized controlled trial. *Journal of Research in Reading*, *45*(3), 406-424. https://doi.org/10.1111/1467-9817.12395

Vesel, J., & Robillard, T. (2013). Teaching mathematics vocabulary with an interactive signing math dictionary. *Journal of Research on Technology in Education*, *45*(4), 361-389. https://doi.org/10.1080/15391523.2013.10782610

West, S. G., Biesanz, J. C., & Pitts, S. C. (2000). Causal inference and generalization in field settings: Experimental and quasi-experimental designs. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 40–84). Cambridge University Press.

Yoon, S. Y., & Strobel, J. (2017). Trends in Texas high school student enrollment in mathematics, science, and CTE-STEM courses. *International Journal of STEM Education*, *4*, 1-23. https://doi.org/10.1186/s40594-017-0063-6

Yusof, J., & Malone, J. (2003). Mathematical errors in fractions: A case of Bruneian primary 5 pupils. At the *26th Annual Conference of the Mathematics Education Research Group of Australasia*.

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational psychologist*, *25*(1), 3-17. https://doi.org/10.1207/s15326985ep2501_2

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In *Handbook of self-regulation* (pp. 13-39). Academic Press.

Zimmerman, B. J. (2013). From cognitive modeling to self-regulation: A social cognitive career path. *Educational Psychologist*, *48*(3), 135-147. https://doi.org/10.1080/00461520.2013.794676

Zimmerman, B. J., & Schunk, D. H. (2001). Reflections on theories of self-regulated learning and academic achievement. In D. H., Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (pp. 289-307). L. Erlbaum.

Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, *29*(3), 663-676. https://doi.org/10.3102/00028312029003663

Żywno, M. S. (2003). Hypermedia instruction and learning outcomes at different levels of Bloom's taxonomy of cognitive domain. *Global J. of Engng. Educ*, *7*(1), 59-70. http://www.wiete.com.au/journals/GJEE/Publish/vol7no1/Zywno.pdf

Appendix A: The Pretest/ Post-test of Fractions Skills (Arabic Version)

(١)

اختبار لقياس كفاءة أداء الطلبة في اكتساب مهارات الكسور

(المقياس القبلي/ البعدي)

الاسم: **الصف:** **العمر:** **سنة**

المجال الأول: جمع وطرح الكسور

أولا: جمع الكسور

رقم المفردة	المفردة	الدرجة
١	لحساب ناتج $\frac{١}{٢} + \frac{٢}{٣}$ نقوم بالآتي: أ) $\frac{(١+٢)}{(٢+٣)}$ ب) $\frac{(١\times٢)}{(٢+٣)}$ ج) $\frac{(١+٢)}{(٢\times٣)}$ د) $\frac{(١\times٣)+(٢\times٢)}{(٢\times٣)}$	[١]
٢	أوجد ناتج الآتي: $٢ + \frac{١}{٣} =$	[١]
٣	أخذت لين $\frac{١}{٣}$ ساعة لمذاكرة مادة العلوم، $\frac{٢}{٤}$ ساعة لمذاكرة مادة الرياضيات. أوجد الكسر الذي يمثل الوقت المستغرق لمذاكرة مادتيّ العلوم والرياضيات.	[١]
٤	قامت ليلى بإعداد كعكتين لهما نفس الحجم، إذا أكل الضيوف من الكعكة الأولى $\frac{٣}{٤}$ ، ومن الكعكة الثانية نصفها، ما مجموع قطع الكعك التي أكلها الضيوف؟	[١]
٥	 قال عليّ: إن ناتج عملية جمع $\frac{٢}{٣} + \frac{١}{٣} = \frac{٣}{٦}$ هل إجابة عليّ صحيحة أم خاطئة. فسر إجابتك	[١]

يتبع

المجال الأول: جمع وطرح الكسور

ثانيا: طرح الكسور

رقم المفردة	المفردة	الدرجة
١	حوط الإجابة الصحيحة $\frac{٩}{١٢} - \frac{٥}{١٢} =$ أ) $\frac{٤}{١٢}$ ب) $\frac{٤}{صفر}$ ج) $\frac{١٤}{١٢}$ د) $\frac{١٤}{٢٤}$	[١]
٢	أوجد ناتج الآتي: $٢ - \frac{٣}{٥} =$	[١]
٣	حبل طوله $\frac{٣}{٤}$ متر، تم قطع $\frac{٢}{٣}$ متر منه. أكتب الكسر الذي يمثل الجزء المتبقي من الحبل.	[١]
٤	قامت ليلى بإعداد فطيرة تفاح، أكل أخوها ربعها. أوجد الكسر الذي يمثل ما تبقى من الفطيرة؟	[١]
٥	احضر عمر كعكتين لهما نفس الحجم في حفلة الفصل، إذا أكل الطلبة من الكعكة الأولى $\frac{٣}{٤}$ ، ومن الكعكة الثانية نصفها، كم عدد قطع الكعك المتبقية؟	[١]

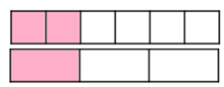
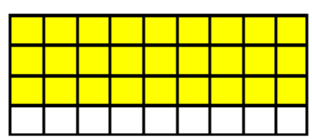
يتبع

(٣)

اختبار لقياس كفاءة أداء الطلبة في اكتساب مهارات الكسور

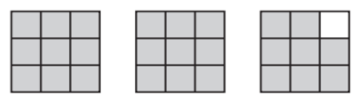
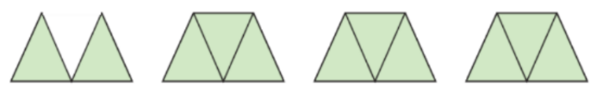
(الاختبار القبلي/البعدي)

الاسم: **الصف:** **العمر:** **سنة**

<u>المجال الثاني: تبسيط الكسور</u>		
رقم المفردة	المفردة	الدرجة
١	حوط الإجابة الصحيحة جميع الكسور الآتية في أبسط صورة ما عدا: أ) $\frac{٣}{٤}$ ب) $\frac{٨}{١٢}$ ج) $\frac{١}{٢}$ د) $\frac{٢}{٧}$	[١]
٢	من خلال جدار الكسور المعروض أمامك، أبسط صورة للكسر $\frac{٢}{٦} = \frac{....}{....}$ 	[١]
٣	إذا كان $\frac{٣٥}{١٠٠} + \frac{١٥}{١٠٠} = \frac{س}{٢}$ فما قيمة س؟	[١]
٤	ارسم شريط مكون من ١٠ أقسام، ثم ظلل ٤ أجزاء منه. أكتب الكسر الذي يمثل الجزء المظلل في أبسط صورة.	[١]
٥	قالت ماريا إن أبسط صورة للشكل أدناه هي $\frac{٩}{١٢}$ ؛ لأن العامل المشترك لأكبر لتبسيط الكسر هو ٣.  هل تتفق مع ماريا؟ نعم لا. فسر إجابتك.	[١]

يتبع

<u>المجال الثالث: تحويل الكسور غير الاعتيادية إلى أعداد كسرية</u>

رقم المفردة	المفردة	الدرجة
١	حوط الإجابة الصحيحة عند تحويل الكسر غير الاعتيادي ($\frac{٦}{٥}$) إلى عدد كسري فإن الكسر يصبح: أ) ١ $\frac{١}{٥}$ ب) ٦ $\frac{١}{٥}$ ج) ٥ $\frac{١}{٦}$ د) ١ $\frac{٦}{٥}$	[١]
٢	استخدم الشكل الذي أمامك لكتابة العدد الكسري.  $\frac{٢٦}{٩} = \frac{٨}{....}$	[١]
٣	استخدم الشكل المعروض أمامك لتحويل الكسر غير الاعتيادي إلى عدد كسري  $\frac{١١}{....} = \frac{٢}{....}$	[١]
٤	أكتب الكسر $\frac{١٧}{٦}$ في صورة عدد كسري	[١]
٥	أعدت سارة ٤ كعكات لحفلة للأطفال، ثم قطعت كل منها إلى ٦ أجزاء. أكل الأطفال معظم أجزاء الكعك، ولم يتبقى سوء خمس قطع. أكتب عدد القطع التي أكلها الأطفال في صورة كسر غير اعتيادي.	[١]

انتهت الأسئلة

Appendix B: The Pretest/ Post-test of Fractions Skills (English Version)

(1)

Name: ………………………………………… Grade: / Date: / / 2024 Age: ( )

First Skill. Fractions Computation (Addition with fractions)		
Item Number	Item	The Score
1	To evaluate $\frac{1}{2}+\frac{2}{3}$, we do the following: a. $\frac{(1+2)}{(2+3)}$ b. $\frac{(1\times2)}{(2+3)}$ c. $\frac{(1+2)}{(2\times3)}$ d. $\frac{(1\times3)+(2\times2)}{(2\times3)}$	[1]
2	Evaluate the following: $2+\frac{1}{3}=$	[1]
3	Lynn took $\frac{1}{3}$ hours to study science and $\frac{2}{4}$ hours to study math. Find in fraction form the time taken to study science and math. .	[1]
4	At the party, Lila brought two cakes of a similar size. The guests ate $\frac{3}{4}$ of the first cake and half of the second one. How many pieces of cake were eaten?	[1]
5	 Ali said “ The product of $\frac{2}{3}+\frac{1}{3}=\frac{3}{6}$ Is Ali’s statement true or false? Explain.	[1]

(2)

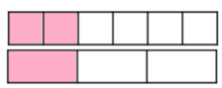
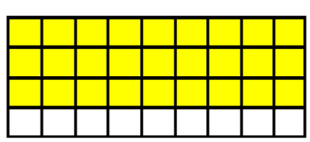
First Skill. Fractions Computation **Subtraction with fractions**		
Item Number	Item	The Score
1	Select the correct answer. $\frac{9}{12} - \frac{5}{12} =$ a. $\frac{4}{12}$ b. $\frac{4}{0}$ c. a. $\frac{14}{12}$ d. $\frac{14}{24}$	[1]
2	Evaluate the following: $2 - \frac{3}{5} =$	[1]
3	A rope is $\frac{3}{4}$ meters long, if we cut $\frac{2}{3}$ meters of it. Find the fraction that represents the remaining part of the rope.	[1]
4	Laila made an apple pie. Her brother ate a quarter of it. Find the fraction that represents the remainder of the pie.	[1]
5	At a party, Omar brought two cakes of a similar size. The guests ate $\frac{3}{4}$ of the first cake, and a half of the second. How many pieces are left?	[1]

(3)

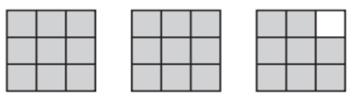
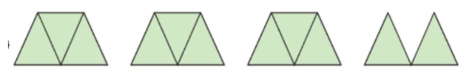
The Pretest/ Post-test of Fractions Skills

Name: ………………………………………… Grade: / Date: / / 2024 Age: ( )

Second Skill. Simplifying Fractions

Item Number	Item	The Score
1	All the following fractions are in simplest form except: a) $\frac{3}{4}$ b) $\frac{8}{12}$ c) $\frac{1}{2}$ d) $\frac{2}{7}$	[1]
2	Use a Fraction Wall to simplify the following fraction:  $\frac{2}{6} = \frac{\ldots\ldots}{\ldots\ldots}$	[1]
3	$\frac{35}{100} + \frac{15}{100} = \frac{x}{2}$. The value of x is …...	[1]
4	Draw a bar with 10 sections, then shade 4 of them. Write the fraction that represents the shaded part in simplest form.	[1]
5	Maria said that the simplest form of the figure below is $\frac{9}{12}$ because the greatest common factor to simplify the fraction is 3.  Do you agree with Maria? Yes or No? Explain	[1]

(4)

Third Skill. Converting Improper Fractions into Mixed Numbers		
Item Number	Item	The Score
1	Select the correct answer When converting the improper fractions ($\frac{6}{5}$) into a mixed number, the answer will be: a. $1\frac{1}{5}$ b. $6\frac{1}{5}$ c. $5\frac{1}{6}$ d. $1\frac{6}{5}$	[1]
2	Use the following figure to write the mixed number.  $\frac{26}{9} = \cdots \frac{8}{\dots\dots}$	[1]
3	Use the following figure to fill in the blank:  $\frac{11}{\dots} = \cdots \frac{2}{\dots}$	[1]
4	Convert ($\frac{17}{6}$) into a mixed number	[1]
5	Sarah prepared 4 cakes for a children's party and cut them into 6 parts. The children ate some of them, leaving five pieces after the party. Write the pieces that children ate as an improper fraction.	[1]

The end

Appendix C: Social Validity Scale

The social validity scale of the study consisted of 15 items distributed into three dimensions on a 5-point Likert-type scale (5 = Always to 1 = Never) with one open-ended question. The questions were on three dimensions: (a) The Learning Setting (i.e., the timing of the fraction class was adequate); (b) The learning materials (i.e., the instructor's teaching of the lessons was clear); (c) The strategy Learned (i.e., Strategies used to teach fractions skills). The table below shows the scale.

n	The Social Validity Scale	5	4	3	2	1
First dimension: The Learning Setting						
1	Instructions about the location and timing of learning sessions were clear					
2	The learning environment was appropriate for receiving learning sessions					
3	The learning session did not conflict with my academic classes in school					
4	The time duration for presenting the instructional sessions was convenient					
5	The learning session timing was convenient for me to complete learning tasks					
Second dimension: Learning Materials						
1	The purpose of learning each strategy used in the learning session was clear					
2	The teacher's presentation of the learning content clear					
3	I had provided me with the required learning materials to practice the strategy					
4	The instructions about the learning materials in each session were clear					
5	The activities and tasks presented in the instructional sessions were practical					
Third dimension: The Strategies Learned						
1	FILMS set lessons and self-regulation strategy improved my skill in adding fractions with unlike denominators.					
2	FILMS set lessons and self-regulation strategy improved my skill in subtracting fractions with unlike denominators.					
3	CUT set lessons and self-regulation strategy improved my skill in simplifying fractions.					
4	EDIT set lessons and self-regulation strategy improved my skill in converting improper fractions into mixed numbers					

5	My performance in mathematics in the regular classroom improved after learning the three strategies for learning fraction					

Note. 1= always, 5= often=4, sometime=3, rarely=2, never=1.

Feel Free to write any other observations or personal thoughts:

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………

Appendix D: Fidelity of Treatment

For the Fidelity of Treatment, the investigator used a checklist. The checklist consisted of 14-17 items distributed into three dimensions. The items in the second dimension differ from one checklist to another to assess the teaching procedures using SRSD fractions. The checklist has only two possible responses: Yes (1) or No (0). The table below outlines the checklist dimensions and the related items.

<table>
<tr><th>n</th><th colspan="2">Fidelity of Treatment</th><th>Yes</th><th>No</th></tr>
<tr><td colspan="3">First dimension: Learning Setting</td><td></td><td></td></tr>
<tr><td>1</td><td colspan="2">Did the teacher provide the learning session for students in the treatment group in person in the school building?</td><td></td><td></td></tr>
<tr><td>2</td><td colspan="2">Did the teacher use an appropriate learning environment for teaching students in the treatment group in the school?</td><td></td><td></td></tr>
<tr><td>3</td><td colspan="2">Did the students in the treatment group miss their regular academic classes during the school day to attend the study's learning session?</td><td></td><td></td></tr>
<tr><td>4</td><td colspan="2">Did the fraction learning session duration for teaching students exceed 40 minutes?</td><td></td><td></td></tr>
<tr><td>5</td><td colspan="2">Did the fraction learning session duration for teaching students require less than 30 minutes?</td><td></td><td></td></tr>
<tr><td colspan="3">Second dimension: Teaching Procedures Using SRSD (Select one lesson only)</td><td>Yes</td><td>No</td></tr>
<tr><td>1</td><td rowspan="7">Lesson (1)</td><td>Did the teacher review background knowledge?</td><td></td><td></td></tr>
<tr><td>2</td><td>Did the teacher set a context for student learning?</td><td></td><td></td></tr>
<tr><td>3</td><td>Did the teacher develop strategy and self-regulation during the lesson?</td><td></td><td></td></tr>
<tr><td>4</td><td>Did the teacher discuss the (FILMS/CUT/EDIT) Steps?</td><td></td><td></td></tr>
<tr><td>5</td><td>Did the teacher provide the Learning Contract to obtain their commitment to learn the strategy?</td><td></td><td></td></tr>
<tr><td>6</td><td>Did the teacher activate memorization practice with the students during the lesson?</td><td></td><td></td></tr>
<tr><td>7</td><td>Did the teacher wrap up (end the session with a positive praise statement)?</td><td></td><td></td></tr>
<tr><td>1</td><td rowspan="6">Lesson (2)</td><td>Did the teacher establish the context for students' learning during the lesson?</td><td></td><td></td></tr>
<tr><td>2</td><td>Did the teacher develop strategy and self-regulation during the lesson?</td><td></td><td></td></tr>
<tr><td>3</td><td>Did the teacher model the (FILMS/CUT/EDIT) Steps?</td><td></td><td></td></tr>
<tr><td>4</td><td>Did the teacher reinforce the student's performance?</td><td></td><td></td></tr>
<tr><td>5</td><td>Did the teacher develop Self- Instructions?</td><td></td><td></td></tr>
<tr><td>6</td><td>Did the teacher activate memorization practice with the students during the lesson?</td><td></td><td></td></tr>
</table>

7		Did the teacher wrap up (end the session with a positive praise statement)?		
1	Lesson (3) Or, (4)	Did the teacher establish the context for students' learning during the lesson?		
2		Did the teacher support strategy and self-regulation during the lesson?		
3		Did the teacher reinforce the student's performance?		
4		Did the teacher develop Self- Instructions?		
5		Did the teacher activate memorization practice with the students during the lesson?		
6		Did the teacher wrap up (end the session with a positive praise statement)?		
1	Lesson (5)	Establish the Context for Student Learning		
2		Support the Strategy and Self-Regulation		
3		Did the teacher reinforce the student's performance?		
4		Did the teacher wrap up (end the session with a positive praise statement)?		
Third dimension: The Class Materials			**Yes**	**No**
1	Was the teacher's presentation of the learning content clear?			
2	Did the teacher provide the students with the required learning materials to practice the strategy?			
3	Did the teacher provide the students with clear instructions about the class learning materials?			
4	Were the activities and tasks presented in the instructional sessions practical?			
5	Was the class time convenient for students to complete their work on class activities?			

Feel Free to write any other observations or personal thoughts:

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