The Relationship Between the Learning Styles of Students in Grades Five and Six and Their Held Misconceptions About Dividing Fractions Based on Kolb's Model

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By

Yousef Mahmoud Abosalem, M.Sc.

A thesis submitted in fulfillment

of the requirements for the degree of

DOCTOR OF EDUCATION

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ABSTRACT

As a school subject, mathematics has a remarkable influence on student's performance in other subjects. Having deficiencies in mathematics is considered a critical problem for students. Students' success or failure in mathematics at the school level has a direct impact on further education and choice of a career (OECD 2010). Fractions, in particular, is a difficult mathematical topic with students encountering difficulties in performing and comprehending operations that involve the use of fractions (Nunes & Bryant 2008). Several studies have found that students' learning styles have an effect on students' performance or academic achievement in mathematics in general and in fractions in particular (Rochford & Mangino 2006). Therefore, this study was conducted to examine if there is a relationship between two grade five and six students' learning styles according to the Kolb's Learning Style Inventory, and their misconceptions in dividing fractions. The study was conducted on a sample of 1864 students from grades five and six selected randomly from fifteen public schools in Abu Dhabi in the academic year 2011/2012. A quantitative approach and two data collection instruments (Kolb's LSI and mathematics diagnostic test) were employed to gather data. The data were analyzed by using descriptive statistics specifically proportion tests, and the Chi- Square $\left(\chi^2\right)$ Independence Test. The results of this study revealed that the dominant learning style of both grades is convergent with 724 students (38.84%), 34.70% for grade five and 42.92% for grade six. The next dominant learning styles were assimilating with 23.35% and accommodating with 21.73% for grade five. While diverging and accommodating in grade six are the next dominant learning styles with 23.54% and 18.00% respectively. Moreover, the analysis of the Chi-Square $\left(\chi^2\right)$ independence test indicated that students' learning styles varied from grade to grade. With respect to students' misconceptions on dividing fractions, the results indicated that the two grades hold the same misconceptions. The first one is flipping the dividend with 31.81%. Coming in at the close second is the lack of fraction concepts with 28.96%, and finally multiplying without flipping with 28.70 %. The answer to the main question, which aimed to examine the relationship between students' learning styles and their misconceptions in dividing fractions, is that the relationship is indeed statistically significant at $\alpha = 0.05$.

ملخص

تعتبر مادة الرياضيات من المواد التي لها تأثير ملموس ومباشر في عملية التعلم والتعليم. إن ضعف الطلاب في هذه المادة يعتبر أو يشكل مشكلة حقيقية لهم و نجاحهم أو فشلهم في هذه المادة له تأثير مباشرفي إختيار الوظيفة المستقبلية لهم (OECD 2010) . لذلك إعتبرت كثير من الدراسات (Nunes & Bryant 2008) ا لكسور من المواضيع الصعبة التي يواجه فيها الطلبة صعوبات عند تعلمهم واجرائهم العمليات الحسابية عليها.

في المقابل أظهرت دراسات أخرى (e.g., Rochford & Mangino 2006) إلى أن معرفة نمط التعلم لدى الطلبة له تأثير ايجابي على أدائهم أو تحصيلهم الأكاديمي في الرياضيات بشكل عام وفي الكسور بشكل خاص. لذلك تم اجراء هذه الدراسة من أجل معرفة فيما إذا كان هناك علاقة بين أخطاء طلبة الصفين الخامس والسادس في عملية قسمة الكسور وطريقة تعلمهم حسب قائمة كولب. بإستخدام منهج البحث الكمي تم جمع البيانات باستخدام قائمة كولب وإختبار تشخيصي في مادة الرياضيات. تم اجراء هذه الدراسة على عينة عشوائية مكونة من 1864 طالبا" وطالبة من طلبة الصفين الخامس والسادس تم اختيارهم من خمسة عشر مدرسة حكومية تابعة لمجلس ابوظبي للتعليم للسنه الدراسية 2011 / 2012 . تم تحليل البيانات المستخرجة بواسطة اداتا الدراسة بإستخدام الاحصاءات الوصفية ، اختبار التناسب واختبار كاي تربيع المستقل $\left(\chi^2\right)$.

أظهرت نتائج هذه الدراسة أن نمط التعلم السائد لدى طلبة الصفين الخامس والسادس هوالنمط التقاربي للتعلم. حيث بينت النتائج الى أن 724 طالبا" وطالبة (34.84 %) منها 34.70 % من طلبة الصف الخامس و 42.90% من طلبة الصف السادس يستخدمون النمط التقاربي في تعلمهم للرياضيات. في حين أظهرت نتائج هذه الدراسة أن نمط التعلم الذي يلي النمط التقاربي هو النمط الإستيعابي بنسبة 23.35% ، يليه النمط التكيفي بنسبة 21.73 % لدى طلبة الصف الخامس. بينما توصلت هذه الدراسة الى أن النمط التباعدي والتكيفي هما النمطان اللذان يليان النمط السائد لدى طلبة الصف السادس وبنسبة 23.54% و 18.0 % على الترتيب. كما أظهرت نتائج تحليل كاي تربيع أن طرق التعلم لدى طلبة الصفين تختلف باختلاف صف الدراسة.

أما بالنسبة لأنماط الأخطاء التي يقع فيها طلبة الصفين الخامس والسادس في عملية قسمة الكسور، فقد توصلت هذه الدراسة إلى أن كل من طلبة الصفين قد وقعوا بنفس الأخطاء وقد تمثلت أنماط الأخطاء لديهم في أنماط ثلاثة ، النمط الأول تمثل في قيام الطلبة عند إجارائهم عملية قسمة الكسور بقلب المقسوم بدلا" من المقسوم عليه بنسبة 31.81 %، والنمط الثاني تمثل في الضعف في مفاهيم الكسور بنسبة 28.96% وأخيرا" الضرب بدون قلب الكسر الثاني(المقسوم عليه) بنسبة 28.70 %.

أخيرا" أظهرت نتائج تحليل السؤال الرئيسي في هذه الدراسة أن هناك علاقة ذات دلالة احصائية عند مستوى الدلالة $\alpha = 0.05$ بين أنماط الأخطاء السائدة لدى طلبة الصفين الخامس والسادس وطريقة تعلمهم حسب نموذج كولب للتعلم

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CHAPTER I
INTRODUCTION

Mathematics is a human activity that includes studying, representing, and investigating patterns and relationships between mathematical objects and other human sciences. As a school subject, it has a remarkable effect. Having deficiencies in mathematics is considered a critical problem for students. Students' success or failure in mathematics at the school level has a direct impact on further education and selecting a career (OECD 2010). Additionally, it is an important subject which has an effect on all aspects of our lives. It is one of the most needed sciences in formal education, employment and day-to-day life (Miller, Butler & Lee 1998). However, mathematics has been considered troublesome for many students in all academic levels around the world. This situation is clear when student are compared with regard to mathematical achievement for grades four and eight students across different countries (OECD 2010; TIMSS 2007). The results of TIMSS (2011) reported that UAE grade four students were at the bottom of the scoring list with an average of 434 for grade four and 456 for grade eight students.

Difficulties in mathematics exist in different mathematical topics such as computation, algebra, and to an even greater degree with fractions. One of the goals of teaching mathematics at all academic levels is that students should be able to understand and use mathematical concepts in different situations. However, the teaching and learning of mathematics is suffering from many problems that are cognitive and non-cognitive (e.g., anxiety and attitudes) in nature, such as deficiencies in students' mathematical skills and learning experiences (Galagedera 1998; Batanero et al. 1994), as well as low mathematics achievement. Besides, teachers usually focus on developing mathematical skills instead of the comprehension of mathematical concepts and misconceptions (Niss 1999). Moreover, students apparently learn mathematical concepts in arithmetic and algebra without comprehending these concepts; they are not able to perform mathematical operations that include these concepts and they are engaged in activities that not been instructed by their teachers (Hill, Ball, & Shiling 2008; Tall & Vinner 1981). Educators use different approaches, therefore, to help students to avoid misconceptions in mathematics in general and in dividing fractions specifically. These approaches involve concentrating on key concepts needed to perform a mathematical problem with fractions, analyzing the problem for relevant information, focusing of students' learning style preferences and focusing the instruction towards these preferences (English 1998). Some of these methods have been successful in helping students to overcome their misconceptions, such as including students' learning styles and providing direct instructions.

Extensive studies in mathematics education have been conducted to find out students' misconceptions in mathematics in general and about fractions in particular, and to determine the relationship between students' learning styles with respect to other variables such as gender, grade, and achievement level. Since misconceptions are considered a means of learning (Flesher 2003; Eggleton & Moldavan 2001; Monaghan 2000) and important for finding the ways in which students comprehend and represent mathematical problems internally, determining the connection between students' misconceptions on dividing fractions and their learning styles allows teachers and educators to focus on students' mathematical knowledge to modify these misconceptions. Pursuing such an endeavor is important since identifying the relationship between the existences of misconceptions about dividing fractions and learning styles will fill the gap in educational studies that have tried to clarify such a relation. Therefore, in this chapter, the importance of conducting this study, statement of the problem, research questions and hypotheses, definition of terms, the study's limitations, and the overview of the dissertation will be presented and documented.

Why Fractions?

Many studies have indicated that a large percentage of students lack basic fraction skills and encounter difficulties in performing problems involving fractions (Idris & Narayanan 2011; Yea-Ling 2005; Burler et al 2003; Rittle-Siegler, & Alibali 2001; Mix, Levine, & Huttenlocher 1999; Hecht 1998; Ball 1990a). The study of fractions is foundational in mathematics and other subjects and yet it is considered to be the most difficult of topics for students to comprehend (Newton 2008; Tanner 2008; Cramer et al. 1997). This situation will negatively impact the students' academic achievements in mathematics and on their cognitive development in future (Orhun & Orhun, 2007). Many research studies (Charalambous & Pitta-Pantazi 2007; Smith 2002) have indicated that the fraction is one of the most sophisticated mathematical concepts (Calhoon et al. 2007; Maccini et al. 2007; Lamon 1999; Niemi 1996 ; Behr et al. 1992; Post et al. 1985). It is also a challenging area (Chen & Kulm 2009; Clarke & Roche 2009; Ross & Bruce 2009; Tariq 2008; Litwiller & Bright 2002; Lamon 1999) that students at different academic levels encounter, posing serious difficulties or deficiencies in comprehending, performing fraction operations, and in developing other mathematical topics or concepts, including algebra (Mazzocco & Devlin 2008; Stafylidou & Vosniadou 2004; Mack 1995; Smith 1995). Furthermore, they experience significant fear and feelings of failure when they are asked to solve problems involving fractions (Ruedy & Nirenberg 1990 cited in Knowlton & Simms 2010). Pitkethly & Hunting (1996) argue that the difficulties facing students in learning fractions are due to the different interpretations of fractions, the transition from whole number arithmetic to fraction arithmetic, and their lack of knowledge of whole numbers. Margaret and Rodzwell (2000) and Peker (2009) indicate that most of the difficulties faced by students with respect to fractions are a result of the type of instruction they are given and the fact that many students think that fractions are always smaller than one. In addition, some students believe that a fraction always increases in value if the numerator and denominator are increased. Also, Burns (2000) believes that students face difficulties in fractions because "they are unable to see a fraction as something to be counted as well as something is a quantity" (p.223). Also, Fractions are described by teachers and students as being complex in nature and as very vital, since they are considered an important pre-requirement for comprehending other number categories and algebra in the students' future school experience. Brizuela (2005) indicates that one of the frustrating areas for both teachers and students is the study of fractions. One of the reasons for these difficulties as reported by Hanson (2001) is that students want to memorize methods instead of comprehending the underlying concepts behind fractions. Whereas, Lamon (2001) states that students' difficulties in fractions are due to the various definitions or interpretations that have been given in mathematics curricula and mathematics education research studies. Kieren (1988) identifies five sub-constructs or interpretations- part whole, quotient, ratio, operator, and measure- to clarify the meaning of fractions/rational numbers. The first sub-construct considers a fraction to be a measure. The fraction $\frac{a}{b}$, according to this definition, can be interpreted as a distance of $\frac{a}{b}\ units$ from **0** on the number line. The second interpretation considers a fraction to be an operator. For example, the fraction $\frac{a}{b}$ of something represents stretching or shrinking. As a quotient, in the fraction $\frac{a}{b}$, $\boldsymbol{a}$ is divided by ***b***, which is the amount that each person gets. Finally, as a ratio, the fraction $\frac{a}{b}$ means, according to this definition, (***a)*** parts of set **A** to (***b)*** parts of set **B**. However, most middle-grades mathematics' curricula in many countries adopt the definition of a fraction as a part of whole far more often than other definitions of fractions because this interpretation gives students the chance to be involved in activities such as drawing and cutting. However, this interpretation causes problems and confusion for students, especially in relating fractions to real-life situations (Ni & Zhou 2005; Thompson & Saldanha 2003). One of these problems is related to representing negative fractions according to the part-of-a-whole interpretation. Also, it is not easy for middle-grade students to imagine a fraction with a large numerator and a denominator such as $\frac{245}{376}$. Furthermore, this definition could cause misconceptions in comparing two or more fractions. Finally, according to this interpretation, improper fractions can be confusing for students. According to Mack (2000; 1993), one student, in representing the fraction $\frac{5}{2}$, wrote that there could not be "five parts of an object that is divided into two parts" (p.435).

Regardless of the situation in which students utilize fractions, it is agreed that this subject offers teachers an opportunity to understand the general development in students' understanding of the connection or relationship between numbers (Porteous 1990). These understandings are constructed through the students' goal achievement, perceptions, and mathematical knowledge achieved in the classroom (Brinker 1998; Bezuk & Bieck 1993).

Many studies reflect and document students' difficulties in learning fractions. In an early study conducted by Hartung (1958), it is agreed that the concepts behind fractions are complex, cannot be digested easily all at once, and must be gained through a gradual and sequential development. Along with that, Orton (1992) agrees that the fraction concepts are gained and developed over a long period, as students experience the different meanings of fractions in different situations over time. Additionally, Bezuk and Biek (1993) mention that this topic creates more problems for both elementary and middle school students than any other mathematical topics.

Based on the difficulties reported by the researchers above, it is to be recommended that in teaching fractions, teachers should expose students to examples or situations that include other mathematical concepts, such as number, length and money; these concepts should be presented in significant applications to which students can relate or connect.

More recent researches conducted on fractions (Trena, Tommy& Jane 2012, Mulligan 2011, Cramer, et al. 2010; Chen & Kulm 2009; Clarke & Roche 2009; Ross & Bruce 2009; Newton 2008; Tanner 2008; Calhoon et al. 2007; Maccini et al. 2007; Tzur 2004; Anderson et al. 2000) have concluded that comprehending and understanding fractions are topics that have usually been difficult for students. National assessment results in the United States (National Council of Teachers of Mathematics (NCTM) 1989) indicate that even high school students show or experience difficulties in working with and comprehending fractions. Moreover, in 1990 the National Center for Educational Statistics in the United States found that only 46% of the twelfth graders who took the National Assessment of Educational Progress Test could consistently solve problems with fractions. Carpenter and his colleagues (1981) in commenting on the Second National Assessment of Educational Progress found that only 44% of eleventh graders could answer correctly the following question:

$$5\frac{1}{4}\ \textit{as the same as}\ \ (a)\ \ 5+\frac{1}{4},\ \ (b)\ \ 5-\frac{1}{4},\ \ (c)\ \ 5\times\frac{1}{4},\ \ (d)\ \ 5\div\frac{1}{4}\ .$$

Kolb (1984; 27) stresses that “learning is a continuous process grounded on experiences.” In other words, it is the process through which knowledge is produced during the transformation of experience and as a dynamic process that an individual engages in, not a result or a product of something created by or done to someone. In addition, learning is a challenge and an opportunity for learners to change and to acquire new knowledge (Kolb & Kolb 2005). There are also learning differences among students. Each student has his/her own learning style which varies significantly, in how he/she learns (Collinson 2000). Some students learn mathematics subjects by reading a lesson many times, some by hearing or listening and some by working or doing. Moreover, some students prefer to learn in teams or groups, whereas others prefer to work individually. According to Felder (1996), some students tend to concentrate on facts, data, and algorithms, while others are happy to focus on theories and mathematical models. Individuals are different in how they tackle a specific mathematical problem. Chin and Brown (2000) indicate that there are clear differences between students in approaching a particular problem. They argue that students who tend to use a more engaged learning style use and express their ideas more spontaneously, give more clarifications and work until resolving the conflict or discrepancies (misconceptions) in their knowledge. On the other hand, students who used to employ surface learning style give only a clarification of the question and refer to what is visible, which makes them unable to resolve the discrepancies and results in making misconceptions. For instance, a student solves a problem by analyzing it completely with his/her own ideas or perspective or by imitating the solution to a similar problem, whereas other students may solve it by using one theory but apply it differently in several applications to get the solution. These differences in how students approach a problem could create weak or strong students. If the student uses the appropriate learning style and tries to analyze the problem and use his/her prior mathematical knowledge in tackling the problem, it will enhance the student's strengths and improve his/her mathematical knowledge in different situations. However, if the student in his/her attempts to solve a specific mathematical problem tries to imitate a similar problem, this will create deficiencies in his/her abilities to use his mathematical knowledge if the problem is changed slightly. Those who are weak or have learning difficulties in mathematics (Panah 2010) might make errors or have misconceptions during their attempts due to applying the imitated algorithm, using the inappropriate theory, having a gap in their prior knowledge, or due to differences in learning style or learning habits.

On one hand, many studies (Orhun 2007; Rutz 2003; Mainemelis et al 2002; Alamolhdaei 2001; Kopsovich 2001; Inagaki et al. 2000; Dunn & Stevenson 1997; Rosenthal 1995) have indicated that there is a relationship between knowledge of how students learn and achievement in mathematics and other subjects. Moreover, Dunn and Dunn (1987) and Calvano (1985) argue that learning style has a positive effect on student achievement. Furthermore, Cano (2005), Burke and Dunn (2002), and Dyer and Osborne (1999) all agree that allowing students to learn with their own learning style will improve their achievement. Additionally, other studies have showed that knowing students' learning styles has a positive effect on student performance or academic achievement, especially in entry-level courses (Rochford & Mangino 2006; Rochford 2004; Mangino & Griggs 2003; Matthews 1996; Nelson et al. 1993; Garcia-Otero & Teddkie 1992; Miller, Alway & McKinley 1987; Witkin et al. 1977). In line with the above researchers' conclusions, a meta-analysis of studies conducted between 1980 and 2000 supports the position that matching students' learning style with teaching improves their academic achievement and their attitudes toward learning (Lovelace 2005). Furthermore, many researchers have indicated that comprehending fractions is possible if we let students use their own solutions and learning (Tzur 2004; Bulgar 2003; Mack 1990).

On the other hand, some other studies (Abosalem 1994; Byres & Takahira 1994; Albustanji 1992; Alyounis 1992) indicated that there is a significant statistical relationship between student achievement in mathematics and having misconceptions in finding the least common denominator (LCD) and the greatest common factor(GCF) in adding or subtracting fractions ; i.e., students with low achievement levels are more prone to having misconceptions. Moreover, some studies (Orhun 2007; Orlich et al. 2001; D'Ambrosio & Mewborn 1994) indicated that since students learn mathematics differently, they tend to understand and solve problems through different approaches. Besides, students' knowledge of their learning styles provides self-insight to the challenges they face to solve a mathematical problem (Orlich et al. 2001). Therefore, by knowing these areas of weakness, we can identify students' misconceptions by following the steps, algorithms, or theories employed to get the answer. Furthermore, Thomson and Mascazine (1997) maintain that students' patterns in solving mathematical problems can be investigated in the light of learning style preferences, which can help in identifying the types of misconceptions held by students. Similarly, Beck (2001) argues that knowledge of students' learning styles could serve in diagnosing students' learning difficulties in mathematics. Similarly, Leinhardt et al. (1990) and Alamolhodaei (2001) point out that students' misconceptions regarding functions can result from deficiencies in pictorial skills, which is one of the learning styles or skills required to graph functions. Their results show that weak students with low pictorial skills have more misconceptions in graphing functions. Furthermore, Moore (1994) agrees with the results of Leinhardt et al. (1990) indicating that one of the major sources of students' misconceptions about functions is their poor pictorial skills and understanding of related concepts.

Statement of the Problem

Many studies have documented a very serious problem concerning students' increasing difficulty in grasping mathematical concepts- fractions in particular. This problem was also reported by NCTM, which indicated that students experience difficulties in learning fractions and solving problems with fractions. Additionally, successive results from the Trends in International Study of Mathematics and Science (TIMSS) (2007, 2011) revealed several countries, including UAE, shared similar misconceptions on fractions and other mathematical topics. Many studies have tried to outline the reasons behind this, such as individual achievement, standards, curricula, teaching methods, and learning styles (Abosalem 1994; Byres & Takahira 1994; Albustanji 1992; Alyounis 1992). According to many researchers (Orhun 2007; Orlich et al. 2001; D'Ambrosio & Mewborn 1994), one of the main reasons for students' difficulty in fractions is a mismatch between the mathematical concepts and students' learning approaches. For example, a student would not be able understand mathematical concepts until he was in the formal operation reasoning Piaget stage of development, as concrete experience can only be comprehended during direct experiences.

While some studies on learning styles have focused on the relationship between learning styles and other variables such as individual achievement standards, dropout rate, completion rate, and attitudes about learning (Diaz 1999), others have focused on students' understanding of dividing fractions (Alkhateeb & Nicholls 2001; Warrington 1997; Nowlin 1996; Mack 1990; 1995; Bezuk & Armstrong 1993; Ottino & Snook 1991). For the above reasons, there is potential value in conducting a study to investigate whether there is a relationship between students' learning styles and their misconceptions about the dividing fractions. The results of this study will guide students, teachers and curriculum developers to try in their efforts to match teaching methods with students' learning styles, since the learning cycle can be used as a tool to identify these misconceptions and overcome them at an early stage of schooling (Turkmen & Usta 2007). Additionally, the results will increase teachers' awareness of varying learning styles in order to add flexibility in their teaching methods and improvements in the communication process between the teachers and their students (Demirbas & Demirkan 2007).

Significance of the Study

Students in different academic level tend to hold misconceptions in mathematics in general and in fractions in particular. Students are using different learning styles in performing and processing information. Each student has his/her own way of learning that help him/her in acquire the knowledge and transfer it according to his/her preferences.

Some studies on learning styles have focused on the relationship between learning styles and other variables such as achievement, dropout rate, completion rate, and attitudes about learning (Souleles 2013; Diaz 1999) and others have focused on students' understanding of dividing fractions (e.g., Alkhateeb & Nicholls 2001; Warrington 1997; Nowlin 1996; Mack 1990, 1995; Bezuk & Armstrong 1993; Ottino & Snook 1991). While, other studies concluded that there is a relationship between achievement and held misconceptions. There is also a relationship between achievement and learning styles, and the relationship between students' learning styles and making misconceptions on dividing fractions has not been sufficiently investigated. Therefore, it is vital to conduct a study to determine whether there is a relationship between students' learning styles and held misconceptions about dividing fractions. This study tries to determine the learning style preferences of the grade five and six students in Abu Dhabi according to Kolb's (1985) model of learning and thereby investigate the question of whether there is a statistical relationship between these learning styles and held misconceptions about dividing fractions.

This study will be very important because only a few studies exist (e.g., Orhun 2007; Turkmen 2007; Anzelmo 2006) that investigate a direct connection between learning styles and held misconceptions or having difficulties in mathematics. Accordingly, this study represents an effort to fill a gap in the mathematics education literature in general and to gain insights into UAE students' learning style preferences in particular. Furthermore, the results of this study on finding a relationship between students' errors in dividing fractions and their learning styles would help all stake holders in Abu Dhabi such as decision and policy makers, curricula developer, Abu Dhabi Education Council (ADEC), assessment and evaluation departments, strategic planner , decision makers as well as teachers. Also teachers have to realize the importance of matching teaching methods and students' learning styles to improve students' performance in mathematics and overcome their misconceptions about fractions.

Research Questions

This study was conducted to answer the following questions:

1) What learning styles do the fifth and sixth grade students have when they learn fractions?
2) What differences, if any, exist in learning styles preferences between fifth and sixth grades' students?
3) What types of misconceptions about dividing fractions do students of grade five and six hold?
4) What differences, if any, exist in misconceptions about dividing fractions between fifth and sixth grades' students?
5) What is the relationship between students' learning styles based on Kolb's (1985) model and their misconceptions about dividing fractions?
6) What difference, if any, exist between fifth and sixth grades' students learning styles and the type of fraction misconceptions?

Limitations

While this study is anticipated to contribute to the mathematics education literature, there are a few limitations: the population is limited to students of grade five and six in the Abu Dhabi Emirate only. The learning styles found by this study are limited to those found by Kolb's Learning Style Inventory. Also in this study, no attention was given to the different teaching methods that these students are exposed to. Since students' learning styles differ from topic to topic (Knisley 2002), this study will investigate only the relationship between students' learning styles and held misconceptions about dividing fractions. Finally, this study was conducted in natural settings. This study is an Ex-post facto research since the researcher does not have direct control for the teaching methods, teachers' experiences, and other factors.

These limitations should be kept in mind when making any generalizations regarding other settings based on this study's findings.

Definition of Terms

1) **Fraction**: a fraction is a part of whole.

2) **Fraction Division** $\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \times \frac{d}{c} = \frac{a.d}{b.c}, b, c, \& d \neq 0,\ a, b, c, d \in Z$

3) **Learning Style**: is the method by which the learner receives processes, acquires, and retains knowledge or new information by accommodating, diverging, converging, and assimilating from his environment. This definition is derived from Kolb (1985, 2000) and it can be measured by Kolb's Learning Style Inventory (LSI) version 3.1

4) **Misconception:** a misconception is a "student conception that produces systematic pattern errors" (Smith et al. 1993, p. 119) and can be classified by Newton (2008) classification.

5) **Systematic pattern errors:** is "a repeatedly occurring incorrect response that is evident in a specific algorithmic computation" (Cox 1975, p. 9) and the same error appears in at least 25% of the students for a specific concept or operation (Luneta & Makonye 2010; Riccomini 2005).

Summary

This chapter introduces the study and explains why it is important; it starts with an introduction to the study along with definitions of important variables or terms used in this study. Additionally, the chapter also examines the significance of this study, the statement of the problem, the research questions and hypotheses that will guide this study, the study limitations, and operational definitions for some concepts that will be used during this study.

Overview of the Dissertation

This dissertation is organized into five chapters. Chapter 1 provides an introduction to the dissertation. In this chapter, the background and the rationale for the study, the research questions, and hypotheses are outlined. The significance and statement of the study are clarified. At the end of the chapter, a summary is provided.

In Chapter 2, the literature review explores students' misconceptions on dividing fractions and student learning styles. This chapter provides an introduction to the issue of students' difficulties in performing fractions. Additionally, the conceptual framework that provides a theoretical background for the model that will be used in collecting and analyzing the data is provided here. The learning theories that clarify the issue of misconceptions are documented. At the end of the chapter, a summary is provided.

In chapter 3, the methods involved and the data collection instruments employed in this study are described. The construction of the mathematics diagnostic test and the means of classifying students' errors are clarified and documented. The sample and participants' selection method, the research design, and data analysis techniques are also described in details. Finally, a number of ethical considerations are also mentioned in this chapter. The chapter concludes with a summary to help the reader in understanding the flow of ideas covered in the chapter.

In Chapter 4, the study's results are discussed and its conclusions are linked to the findings of other relevant studies.

In the last chapter (Chapter 5), the study's conclusions and its implications for the relationship between students' misconceptions in dividing fractions and their learning styles are presented along with recommendations for future studies in this area.

CHAPTER II

REVIEW OF LITERATURE

Introduction

This chapter reviews the literature relating to the research questions that are examined in this study. This chapter includes the learning style concept and the theoretical framework that gives the theoretical background for the construct investigated. It covers the varieties of different learning- style models that have been used in many studies to find out students learning styles and the weakness and strengths of each model. Additionally, the rationale for adopting Kolb's learning model as a theoretical framework for this study is presented. Some learning theories that clarify students' misconceptions and errors in mathematics are presented. Misconceptions, knowledge, and dividing of fractions are documented. A short summary ends the chapter.

Several studies around the world have been conducted in the area of fractions (Trena, Tommy& Jane 2012, Mulligan 2011, Cramer, et al. 2010, Mokashi 2009, Stemn 2008, Warren & Cooper 2007, Amato 2005, Suffolk & Clements 2003; Anderson et al. 2000; Hecht 1998; Bana, Farrel & McIntosh 1997; Ball 1990 a) and mentioned the large percentage of students in different levels lacking fraction skills. Yet, an extensive review of the literature has shown a lack of studies that tried to investigate the relationship between students' misconceptions about dividing fractions and learning styles. Therefore, this study will contribute to the educational literature by extending that knowledge from current experiences.

Studies have been conducted internationally to investigate students' difficulties in comprehending fractions (see e.g. Trena, Tommy& Jane 2012; Mulligan 2011; Faulkner 2009, Moone & de Groot 2007; Neumer 2007; Flores & Klein 2005; Mack 1990, 1995, 2000; Gearhart et al. 1999; Brinker 1998). Most of these studies indicate that fractions are a topic that students encounter difficulties with. Additionally, students in middle classes do not comprehend what the fraction symbol represents or means. Moreover, the researchers (Trena, Tommy& Jane 2012; Mulligan 2011; Faulkner 2009, Moone & de Groot 2007; Neumer 2007; Flores & Klein 2005; Mack 1990, 1995, 2000; Gearhart et al. 1999; Brinker 1998) mentioned that teachers' difficulty in understanding fractions is one of the reasons behind students' difficulties in performing and understanding fractions. Knowledge of students’ errors and misconceptions about fractions will help teachers to improve their teaching methods (Borasi 1994).

The literature review below highlights some issues that are related to students’ learning styles and their relationship with held misconceptions about different mathematical topics.

Theoretical Framework

Since this study aimed at investigating the relationship between students learning styles and their misconceptions in dividing fractions. Therefore, two theoretical frameworks were used to guide this study and to help in selecting the appropriate data analysis techniques.

Errors Classification Framework

Different errors classifications were implemented by researchers to categorize students misconceptions in mathematics. For example, Kevin (2002; pp. 1-26) categorizes the most common errors in undergraduate mathematics into; errors in communication, bad handwriting, loss of invisible parentheses, not reading directions, and terms lost inside an ellipsis. Whereas, other researchers (Elbrink 2008; Watson 1980) stated that students errors are originated or rooted in understanding, and transforming process skills. Moreover, Watson (1980; p. 322)classified students’ errors according to the sequence they were committed. Errors are linked to; reading abilities, comprehending the problem, understanding the mathematical concepts mentioned on the questions, transforming (choosing the suitable mathematical process to solve the problem), careless errors, procedural errors, calculation errors, symbolic errors and question ambiguity. Whereas Usman and Harbor (1998) categorized students’ errors committed in solving mathematical problems into; conceptual, translation, logical and applied skills.

In order to classify students’ errors in dividing fractions, the Newton (2008; p. 1100) classification was adopted in this study. This classification consists of ten errors as shown in Table 1. This classification is selected because it covers all possible errors that students might hold in performing fractional problem.

Table 1: Errors classification

S.#	Error type
1	Multiply without flipping
2	Whole-number errors
3	Errors in changing forms(errors in writing the answer in lowest form)
4	Left blank
5	Knowledge of basic fractions concepts errors
6	Added or subtracted numerators or denominators
7	Flipped dividend
8	Cross-multiplied
9	Flip the dividend and the divisor
10	Miscellaneous

(Newton 2008, p. 1100)

Learning Styles Framework

Learning is considered as a process where individuals absorb, memorize and process information to be used in future situations. Moreover, researchers state that there is no ideal way of leaning in a particular situation. Everyone has his/her own learning style which can differ from one situation to the next. Additionally, Pashler et al. (2008) found that individual differences in (taking and processing information) are two important components of learning. Also these differences in learning affect teaching and learning processes for both students and teachers. Moreover, according to Felder and Brent (2005), the more thoroughly instructors understand these differences, the more likely they will be able to fulfill their students' needs and offer diversity.

Research has often mentioned that the students' learning style and the quality of teaching are two important factors in student learning (Stigler & Heibert 1999). As such, the properties of teaching fractions by using traditional techniques do not give consideration to how students learn, which could explain the trend in low achievement in learning fractions. Moreover, both Tzur (2004) and Bulger (2003) demonstrated that comprehending fractions can be attained when students learn them in accordance with their own learning preference. Along with that, Silver (1986:190), referring to students' systematic errors, stated that we have to "examine the possibility that our instructional procedures may be reinforcing the error rather than eradicating it."

In recent years, research into learning styles has become extensive in the fields of cognitive psychology and mathematics education (Peker 2009; Nympha, Joaquin & Milagros 2008; Loo 2002; Weymer 2002; Alamolhodaei 2001; Stuliff & Baldwin 2001; Cano et al. 2000; Oughton & Reed 2000; Phelps 1990). Students show their own learning styles in gathering and classifying information into knowledge that can be used or implemented in future situations. Moreover, Alamolhodaei (2001) considers a student's learning style as a key aspect in what motivates that student to interact or respond to different situations. Learning styles have been the core of many studies in the past thirty years in an attempt to improve instruction and student achievement and to understand how students learn and comprehend content knowledge. Substantial amounts of research have investigated the effect of personal characteristics such as learning styles and personality on how students learn mathematics (Strong et al. 2004; Silver et al. 1997; Brandt 1990; Miller et al. 1987). One of the reasons that some students perform better than others even though they are exposed to the same instruction is their learning style. Therefore, using a successful learning style helps in finding effective ways to acquire new mathematical knowledge. Additionally, Draper (2004;29) indicates that if educators fail to recognize or identify students' learning styles, this could result "in environments not conducive to learning", which means that the teacher might use a teaching approach that not matching with students learning preferences which leads to less interaction between teacher and students . Furthermore, understanding the ways in which students learn is considered by educators to be an effective factor in improving education (Collinson 2000) and avoiding misconceptions in mathematics and science (Turkmen & Usta 2007). Also, Slaats et al. (1999;489) maintains that understanding the "learning styles of students has a wide range of possible applications in education". These applications range from classifying students according to their learning styles to selecting appropriate teaching approaches.

A considerable number of studies have concluded that every student has his/her own learning style preference and that teachers need to be knowledgeable of how students learn (e.g., Peker 2009; Fotoples 2000). Moreover, according to Sternberg and Grigorenko (1997) and Sadler-Smith (1996), the differences between students in terms of their learning preferences are important to the learning process.

These learning differences make teachers to employ different teaching methods to suit students' learning needs and preferences Additionally, Graf et al. (2009) argue that knowledge of students' learning styles can help to improve the learning process and can be used to identify misconceptions during the early stages (Turkmen &Usta 2007). Teachers who know their students' learning styles provide them with a deep understanding in delivering the material in classes. Moreover, students' awareness of their learning styles and identifying their weaknesses and strengths helps them to understand why they are facing difficulties in learning and might help them in overcoming their weaknesses and enhancing their strengths. However, the greatest benefit of knowing students' learning styles is the fact that the responsibility will be on the students themselves. According to Watanabe (2002) and Griggs (1991), students' knowledge and use of their preferred learning styles will help them applying such information, consequently improving their performance and overcoming deficiencies and misconceptions. Therefore, attending to learning styles can help in tackling new or difficult situations and the processing of information (Thomson &Mascazine 1997). Moreover, teachers and educators' knowledge of students' learning style preferences, helps them in organizing classroom activities to meet the individuals' learning needs. Additionally, Burrill (1997) indicates that knowing students' learning styles will help teachers to listen to their students and build on their prior knowledge, which makes learning more effective and meaningful. Moreover, they can concentrate more on when and how a certain mathematical topic, such as fractions, should be delivered, and how much time should be allocated to the material (Naiser et al. 2004).

Several factors affect students' learning performance such as perception of academic control, self-efficacy, culture, goal achievement, motivation, learning style, and cognitive abilities. Riding (1996) differentiates between a student's learning style and his/her cognitive abilities. Learning style, according to Riding ,is how or which method a student uses to process information or knowledge, while cognitive abilities refers to the "capacity to perform higher mental processes of reasoning, remembering, understanding, and problem solving" (Salthouse 2005; p. 533).That is, obtaining the knowledge depends on student's learning style where using the knowledge correctly or appropriately depends on his/her cognitive abilities. Cognitive abilities and students' learning styles have an active role in teaching- learning processes. Students tend to learn differently since they have different cognitive abilities such as awareness, perception, reasoning, imagination, sketching and judgment. These abilities have an effect on how learning occurs (Graf & Kinshuk 2006). Graf et al. (2006) also concluded in their study that there is a relationship between students' cognitive abilities- such as working memory capacity - and their learning styles. Students with low working memory capacity prefer visual learning environment. Additionally, Graf and Kinshuk (2006) indicated that inclusion of students' learning differences and their cognitive abilities in teaching will improve their performance. Many studies (e.g. Indreica, Cazan, & Truta 2011; Dobson 2010) mentioned other factors that have a relationship with student's learning style. One of these factors is student's motivations. However, Sengodan and Iksan (2012) tried to find out what are factors that identify the proper learning style. They found that students' learning styles are connected strongly either to intrinsic or extrinsic motivations. Along with that, Aziz and his colleagues (2006) indicated that there is a positive relationship between motivation and learning styles.

Other researchers (Uzuntiryaki 2007; Dunn & Griggs 1995; Price 2000, 1980) mentioned that students learning styles are varied according to the grade. Also, Jones et al. (2003) who indicated that only 19% of the participants stayed in the same learning style within different disciplines, and their learning styles varied from one subject to another. Additionally, Kaya et al. (2009) in their study that investigated primary school students' learning styles on a sample of 687 students distributed into three grades; six, seven and eight, revealed that there are meaningful differences in students' learning styles according to the grade and that there is a relationship between students' learning styles and class grade at $\alpha = 0.05$. Along with that, Tucker (2008) assured that the learning styles varied from year to year of study. Also, Price (2000) mentioned that environmental, emotional, sociological, and physical traits are stable form grade to grade. However, Price (2000) asserted that student teacher-motivated student decrease from lower grade to higher one. The higher grade student tends to learn with peers especially in grades six through eight. Additionally, the younger the student the more kinesthetic he/she was. Furthermore, Spoon, and Schell (1998) concluded in their study that a statistically significant difference was found between age and learning styles. Moreover, Kolb's (2005) confirmed that there is a relationship between age and learning styles only with convergent students. In contrast with the above researchers, Pallapu (2008) and Reid (2007) concluded that there was no statistical significance between students' learning styles and age. Also, Truluck (1999) concluded by using Kolb's LSI that no significant effects between students' learning styles and their ages and their learning styles were evenly distributed. Also, Kaya, Ozabach and Tezel (2009) reported that all grades that participated in their study were diverging learners, with 39.3 %, 34.6% and 31.6% for the grades six, seven and eight respectively and no significant relationship between students' learning styles and their ages. Additionally, Can (2011) reported in his study that conducted on 409 students that no significant relationships were found for age, gender, and learning style.

Sengodan and Iksan (2012) indicated that intrinsic motivations are more linked to student's learning styles and they mentioned that self- efficacy (how much a student has self-confidence in his/her ability to show an excellent achievement [p. 18], plays an important role in problem- solving ability. Therefore, learning styles and intrinsic motivations are considered by Sengodan and Iksan (2012) as the two important factors that influence students' achievements in mathematics. Also, Rashid (2007) stated that a significant relationship exists between students' learning styles and intrinsic motivation. So that if the student's learning style is coherent with their motivation, the learner discovers his/her competences. Additionally, matching students' learning styles and teaching methods in class allows students to learn mathematics effectively, improve their achievements, reflect different academic strength, weaknesses and skills and reduce misconceptions (Felder &Brent 2005). Since a certain learning style is more appropriate to learn a specific topic (Kolb 1985), any student has learning strengths or weaknesses. The strengths can be enhanced and teachers could rectify the weaknesses if there is a kind of agreement between how students obtain and process knowledge.

One factor or concept specifically which gives some valuable information on students' learning in both academic and other setting is learning style (Cassidy 2004). In the last 30 years of research, learning styles studies have developed and used various comprehensive models indicated that many factors or elements affect students' learning styles. For instance, Keefe (1987) stated that there are three dimensions of individual learning style preferences: cognitive, affective, and psychological styles, whereas Gregorc (1982 cited in Walker et al. 1989) mentioned auditory, tactile/kinesthetic, and visual dimensions that affect students' learning style preferences. Similarly, Dunn and Dunn (1996-2000) (cited in Lovelace 2005) developed a model that has the ability to identify students' learning styles. Their model consists of 26 different learning style characteristics or preferences. These preferences focus on perceptual, psychological, physiological, emotional, and sociological aspects of learning. Finally, Kolb (1985) developed a learning style model that consists of four basic categories focused on convergent, divergent, assimilation, and accommodation learning styles.

Most learning style families have their own assessment tools in the form of a questionnaire. Furthermore, these models include different amounts of questions about different aspects such as personality, attitudes and behavior. Learning style inventories help learners to be familiar with their learning preferences; however, many of them have also limitations and weaknesses related to internal consistency, reliability, construct, and predictive validity.

According to Coffield et al. (2004), there are 71 different learning styles inventories. They divide learning styles inventories into five categories as shown below in Table 2:

Table 2: Families of Learning Styles

Genetic and other constitutionally based learning styles and preferences		
Author(s)	**Assessment tool**	**Year introduced**
Dunn and Dunn	Learning Style Questionnaire (LSQ) Learning Style Inventory (LSI) Building Excellence Survey (BES)	1979 1975 2003
Gregorc	Gregorc Mind Styles Delineator (MSD)	1977
Cognitive Structure		
Riding	Cognitive Styles Analysis (CSA)	1991
Stable Personality Type		
Apter	Motivational Style Profile (MSP)	1998
Jackson	Learning Style Profiler (LSP)	2002
Myers-Briggs	Myers-Briggs Type Indicator (MBTI)	1962
Flexibly Stable Learning Preferences		
Allison and Hayes	Cognitive Style Index (CSI)	1996
Herrmman	Brain Dominance Instrument (HDBI)	1995
Honey and Mumford	Learning Style Questionnaire (LSQ)	1982

Felder and Silverman	Index of Learning Styles (ILS)	1996
Kolb	Learning Style Inventory (LSI) LSI Version 3	1976 1999
	Learning Approaches and strategies	
Entwistle	Approaches to Study Inventory (ASI) Revised Approaches to Study Inventory (RASI) Approaches and Study Skills Inventory for Students (ASSIST)	1979 1995 2000
Sternberg	Thinking Styles	1998
Vermunt	Inventory of Learning Styles (ILS)	1996

(Coffield, et al. 2004 cited in Kanninen 2009, p. 13)

Three of the above families of learning styles will be presented. The first one focuses on human observation channels; vision, hearing and feeling. It is called the Visual-Auditory-Kinesthetic (VAK) inventory. This model, categorizes learning styles into four aspects; Visual (verbal), Visual (non-verbal), Auditory, and Kinesthetic. This inventory according to Coffield et al. (2004) is not a learning style inventory since it is not prepared by a specific person, and the model failed to achieve psychometric criteria such as reliability and validity.

The Honey and Mumford learning style (LSQ) inventory was proposed and developed as an alternative for Kolb's model in 1982, and it consists of four phases with 80 items; activist, reflector, theorist and pragmatist (Kanninen 2009). The inventory was employed widely in management training and education. However, this inventory has some limitations. The majority of its items are behavioral in nature; instead of asking learners how they learn as Kolb's model does, the LSQ inventory explores general tendencies rather than learning. The LSQ can be used for personal and organizational development but not for individual assessment or selection. However, the internal consistency reliability of this inventory is modest and ranges from 0.52 to 0.73 for its phases. Another serious issue in this model is that the four learning styles are orthogonal to one another; that is, a learner may get a high score on one and a low score on the other phases, or a low or high score in all four phases. Moreover, the participants get bored with implementation since it consists of 80 items and it is more task- directed than individuals' oriented. Additionally, only face validity is mentioned on the LSQ manual and no other types of validity have been investigated. Finally, one third of the inventory items failed to discriminate between different learning styles (Duffy & Duffy 2002; Cassidy 2004).

The Third Model: The Experimental Learning Theory (ELT) /Kolb's Model

The Experimental Learning Theory (ELT) has common aspects with the constructivist theory in so far as the student's past experience depends on knowledge abstraction and reflection. Abstraction is the ability of the learner to select, and then combine in his memory a set of items by degrees of experience. The reflection is the processes of the learner's mind, which puts together the reasoning process resulting from the abstraction stage and using this reasoning in real- world contexts or situations. According to Wilson and Bennett (1994), the abstraction process is considered the essential mechanism of learning where mathematical knowledge is produced or generated.

The Experimental Learning Theory (ELT) proposes that individuals "learn by their direct experience, by reflecting on their experience, by conceptualizing and thinking abstractly about the world, and by actively participating in the world" (Koop & Funk 2002; p. 294). Additionally, it describes how experience is translated into concepts (Kolb 1976), which consecutively helps learners in selecting new experiences. This model clarifies the learning process and how individuals learn, grow, and develop intellectually, psychologically, and physiologically (Kopsovich 2001; Kolb 1984, p. 5) through four learning cycles or phases, as shown in Figure 1 and explained in Table 3 below.

Figure 1: Kolb's learning model and basic learning style preferences

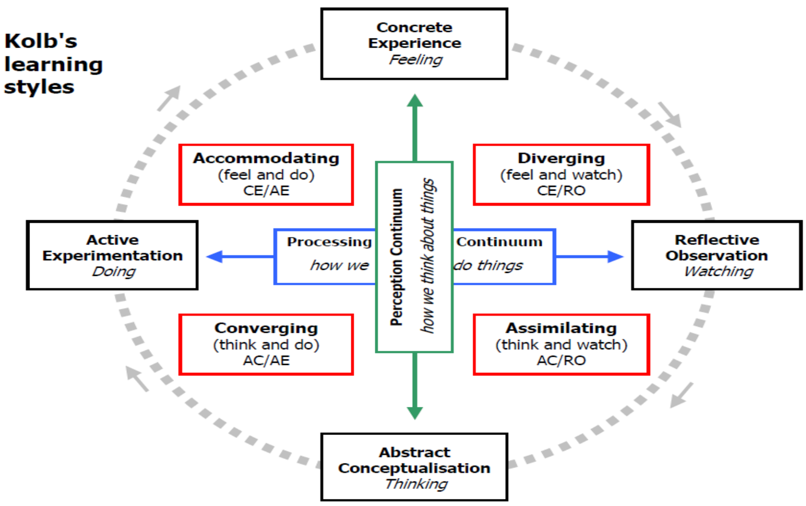


Table 3: Stages of Kolb's Learning Cycle (Kolb 1984, p.5)

Concrete Experience (CE) Learning from feeling • Learning from specific experiences Relating to people • Sensitivity to feelings and people • Open-minded and adaptable to change
Reflective Observation (RO) Learning by watching and listening • Careful observation before making a judgment • Viewing things from different perspectives • Looking for the meaning of things
Abstract Conceptualization (AC) Learning by thinking • Logical analysis of ideas • Systematic planning • Develop theories and ideas to solve problems • Acting on an intellectual understanding of a situation
Active Experimentation (AE) Learning by doing • Ability to get things done • Risk taking • Influencing people and events through action

The ELT theory, rooted in the constructivist work of Kurt Lewin (1890-1947) (social psychology), the cognitive-development processes of Piaget's research (1896-1980), and Dewey's (1859-1952) work on pragmatism philosophy, were a contributing factors in the development of David Kolb's (1985) Learning Styles Inventory (LSI) (Ozkan 2003) to assess individual learning styles. According to Kolb (1985) the learner requires four different abilities to be effective: Concrete Experience (feeling) (CE), Reflective Observation (watching) (RO), Abstract Conceptualization (thinking) (AC), and Active Experimentation (doing) (AE). That is, the learner must be engaged in new experiences (CE). He has to be able to reflect on and examine these experiences from different angles (RO) and he has to be able to produce concepts that incorporate his observations into correct and logical theories (AC). Finally, he has to be able to implement these theories in order to resolve problems (AE).

Based on his learning model, Kolb (1985) formulated the Learning Style Inventory (LSI) to measure learners' strengths and weaknesses and individuals' ways of learning from their experiences (Atkinson 1991; Matthews 1996). It also measures how they perform or use a variety of learning styles that communicate how efficient and comfortable they are when learning (Orhun 2007; Kolb 1985). Also, Smith and Kolb (1986, p. 95) state that the LSI “provides a model of human growth and development. It conceptualizes the learning process in a way that allows users to identify differences among individual learning styles and corresponding learning environments.”

According to Kolb (1984, p. 38), learning is “the process whereby knowledge is created through the transformation of experience.” This process is mediated on four dimensions that consist of: (a) affecting, (b) symbolic, (c) behavioral, and (d) perceptual. Based on the four dimensions, the LSI consists of four basic categories of learning styles listing twelve incomplete statements, each of them with four possible completion phrases (as shown in Table 4). These completion phrases are directly correlated with the four learning cycles or quadrant poles: convergent, divergent, assimilation, and accommodation. In the first category, the learner depends on the dominant skills of abstract conceptualization and active experimentation. In this style, the student prefers to use deductive reasoning and tends to show a good understanding of practical ideas and their application (Healey & Jenkins 2000; Rasckick& Maypole 1998); also the learner tends to solve wrong problems, learn by trial-error and he makes decisions too quickly. In the divergent category, the learner depends on concrete experiences and reflective observation. The students in this category tend to be imaginative, emotional, and feelings-oriented and have the ability to view concrete situations from different angles or perspectives. Furthermore, they are good at creating new ideas and tend to work in groups (Healey & Jenkins 2000; Kolb 1985). Assimilator learners tend to learn through abstract conceptualization and reflective observation. The students in this category like to build theoretical models and implement inductive reasoning and they show an interest in learning mathematics and science. In the last category, learners tend to learn through concrete experience and active experimentation. Moreover, they prefer to perform experiments, try to be involved in new experiences, and they depend greatly on others to get information to solve specific problems.

Based on the four-stage cycle proposed by Kolb (1985), it becomes clear that the learning process needs abilities that are polar opposites. This means that, for students to perform correctly, they need to have concrete experiences and abstract conceptualization or to be active and reflective. A student has to decide which learning skills are needed in a specific learning situation. Every student employs the four learning cycles at the same time, or he/she prefers one stage. The differences between employing one of the learning cycles or all of them might lead to different experiences in dealing with the same learning situation. The incorrect selection of a learning cycle might cause inappropriate answers or misconceptions. For instance, if the learning situation requires the student to use mathematical theories or concepts to solve a specific problem (AE), instead of employing the (AE) learning phase, he uses (CE). Employing CE is helpful in reflecting or observing the learning situation from different angles without making a decision or performing a mathematical problem correctly. Furthermore, it could create a misconception due to the incorrect learning cycle employed.

Table 4: Verbal statements available in Kolb's Learning Style Inventory (LSI)

Statement	Phrase
When I learn …….	– I like to deal with my feelings (CE) – I like to watch and listen (RO) – I like to think about ideas (AC) – I like to be doing things (AE)
I learn by…….	– feeling (CE) – watching (RO) – thinking (AC) – doing (AE)
I learn best when…….	– I am receptive and open minded (CE) – I am careful (RO) – I analyze ideas (AC) – I am practical (AE)

(Orhun 2007, p. 324)

Even though Kolb's model is extensively used by many researchers and in different disciplines such as education (430 studies), management (207 studies) and computer studies (104 studies), many weaknesses exist with the model. Some of these weaknesses are its limited ability to be used in all situations, the fact that it provides only a limited number of factors that affect individual learning, and that it cannot be used for individual selection purposes (Greenway 2004). Furthermore, Kolb's model has low predictive validity and there are criticisms by some researchers on its theoretical background (Vince 1998; Holman & Thorpe 1997; Hopkins 1993), and the three elements of the model- process, level, and style- need to be separated. However, for the purpose of this study, the information-processing model (Kolb's model) will be adopted since the study aims to find the connection between learning styles and held misconceptions. Kolb's (1985) learning model will be employed in this study because it is considered as a mathematical learning style and the most suitable tool to determine a student's learning styles preference in both educational settings and everyday life settings (Knisley 2002; Evans et al. 1998). It has a strong conceptual, theoretical, and experimental foundation that follows Dewey's philosophy (Kolb & Kolb 2005; Healey & Jenkins 2000) with a high Alpha reliability coefficient ranging from 0.81 to 0.88 (Kayes 2005; Kolb & Kolb 2005; Wierstra & DeJong 2002; Matthews 1996; Rubie & Stout 1991; Veres et al. 1991) compared to the Dunn, Dunn, and Price inventory with $r = 0.60$. Additionally, Kolb's model provides a functional framework for the systematic selection of classroom activities that will help in finding out students' strengths and weaknesses. Moreover, it has been used in various disciplines, including engineering, management (Auyeung & Sands 1996), science and mathematics (Orhun&Orhun, 2007), computer education and statistics (Hudak & Anderson 1990). In general, these studies outlined that the LSI is useful in finding out students' preferences, identifying differences between students, and identifying appropriate interventions. Additionally, according to Hay Resources Direct (2001), it has been used in 1320 research studies. Finally, Kolb's model consists of twelve items; while Honey and Mumford learning style (LSQ) inventory consists of 80 items and Dunn's inventory contains 104 questions which makes Kolb's inventory easy to be used for grade five and six students.

Difficulties and Misconceptions in Fractions

A large and growing body of literature has indicated that students exhibited difficulties and errors in fractions (Tzur 1999; Bana et al. 1997; Ashlock 1994; Davis, Hunting, & Pearn 1993; Davis, Alston, & Maher 1991; Steff, Cobb, & Von Glaserfeld 1988). Therefore, it is vital to find out methods or approaches to help students overcome obstacles in fractions. Errors in mathematics in general and in fractions in particular that linked with misconceptions make students in different academic levels make incorrect responses when they perform mathematical questions that depend on these misconceptions. For example, Perso (1991) illustrated the relationship between errors and misconceptions, showing that errors could be due to different reasons such as guising, low mathematical ability, or as a result of low achievement, but they result from systematic rules or methods and are based on misconceptions. Other researchers (Farrell 1992; Bell 1982) have examined different aspects that linked to mathematical errors and misconceptions and their frequencies. Davis (1984, p. 335) mentioned that the number of misconceptions and errors are huge "and a complete list may not even be practical."

A considerable amount of researches (Pinilla 2007; Naiser et al. 2004; Rittle-Johnson et al. 2001; Mix et al. 1999; Hecht 1998; Smith 1995; Saenz-Ludlow 1994; Ball 1990a; Hiebert 1988; Carraher & Schliemann 1987; Behr et al. 1984; Behr et al. 1983; Hasemann 1981) have concurred that most students face substantial problems and misconceptions when learning fractions. Also, according to Kosbob and Moyer (2004), "when children do not understand foundational fraction concepts, they experience difficulties with fraction computation, decimal and percent concepts, and ratio and proportion concepts" (p. 375). It is one of the major areas of failure and a large percentage of students have deficient basic fraction concepts.

The fraction has been described as a difficult topic and students usually encounter difficulties. As a result, students in different ages and academic levels hold misconceptions that will affect their fractions' conceptual development and employing fraction concepts in different situations. Also, fractions and operations on them is one of the most frustrating areas for both teachers and students. Moreover, many researchers stated that students over time forgot how to perform operations on fractions. Additionally, many studies (Ma 1999; Brown, Cooney, & Jones 1990; Carpenter et al. 1981) indicate that elementary teachers and students have been shown to be weak in fractions. One of the reasons behind this according to Hanson (2001) is that students tend to memorize rules or algorithms instead of understanding them. Along with that, Cramer and his colleagues (1997) mention that students experienced difficulties in ordering fractions when two fractions are equal and in the representation of the fraction on the number line. Therefore, students supposed to understand or comprehend fractions' concepts well before asking them to perform operations on fractions.

Not only do students in elementary, middle, and high school suffer and demonstrate difficulties in learning fractions, but also many teachers indicated that it is one of the hardest topics to teach (Shamsiah & Clements 2002). Additionally, they confirmed that students could not relate fractions' symbols with fractions' expressions such as a fourth of sixteen. Several research results (D'Ambrosio & Mewborn 1994; Baroody & Hume 1991; Streefland, 1991) presented many factors that contribute to difficulties in learning fractions for students:

1) The teachers are using their teaching visual aids that are prepared prior to the class without involving students in manipulating or preparing them. Moreover, the way the curriculum is presented does not give students opportunities to be exposed to different forms of fractions.
2) The inappropriate interpretation of the connection between whole-number line or scheme and the digits of fraction.
3) The poor classroom environment that helps in using different representations of fractions.

Orhun (2007) and Baroody and Hume (1991) assert that students' errors in fractions are a result of misunderstanding of underling concepts and different representations and meanings of fractions. Markovits and Sowder (1991), in their study to investigate types of errors made by students in comprehending fractions, state that one of the reasons is that students are not able to understand the relationship between fractions and decimal interpretations of rational numbers.

As mentioned in the above studies, fractions are described as a difficult topic for students to understand and are "tough for kids" (Neimi 1996; p. 75). Neimi thinks that difficulty is due to the way fractions are presented in mathematics curricula, and students are only involved in quantitative activities that have been a variety of counting operations containing units. Wu (2002) and Sophian (2000) mentioned that instruction on fractions and the lack of a clear definition of a fraction are major reasons behind student's difficulties in learning fractions. According to Wu (2002), students' difficulties in learning fractions are due to the fact that fractions do not fit well with students' previous ideas about numbers, which only provide a background for learning counting and relating whole numbers but are not supporting learning fractions. As a result of this, fractions do not fit well with students' knowledge; the students are not prepared for the transition to fractions and rational numbers stages.

In addition, Pitkethly and Hunting (1996) agree that fractions are not easy for students to comprehend. Fractions are an important topic but a difficult part of mathematics, and a great deal of evidence has been presented by researchers indicating that students still perform poorly on fractions at different academic levels; even students at the college level are still making mistakes in dividing fractions similar to ones that younger students make (Tirosh 2000; Ball 1990b).Therefore, it is vital for mathematics teachers to get away from traditional teaching methods and provide their students with activities that help students in building their conceptual understanding, which refers to “mathematical knowledge and how students learn. Moreover, conceptual understanding or knowledge of mathematics has two levels: understanding of an idea within a specific context and understanding of ideas in an abstract sense” (Cramer et al. 2002, p. 124).

Many misconceptions and learning difficulties involving mathematical concepts and operations depend on individuals’ experiences and employing these concepts in everyday life (Ashlock 1994). These misconceptions are not careless or random but occur frequently and repeatedly (Brumfield & Moore 1985; Cox 1975), and students are misapplying algorithms in solving fractional problems. Studying students’ misconceptions will give an indication of their proficiencies in mathematics and reasoning and of the nature of competent performance and learning. Misconceptions are considered by many researchers (Santagata 2005; Hartentt & Gelman 1998) as a part of the learning process and can be interpreted based on the learner’s existing structure knowledge. Furthermore, misconceptions can offer teachers with teaching methods or techniques that help students to produce their own learning during instruction. The systematic occurrence of errors is an indicator of lack of mathematical knowledge for that topic (Dole 2003); the student has the ability to learn, but minimal learning has occurred and it is not enough to solve mathematical problems. Furthermore, the student has learning difficulties, tends to have misconceptions in solving mathematical problems, and has learned in a way that is either different than it is supposed to be or inappropriate (Dole 2003; Ashlock 1994; Confrey 1990; Resnick et al. 1989).

Individuals come to mathematics instruction with different sets of misconceptions concerning fractions and other mathematical subjects, such as algebra (Falkner et al. 1999). In the Piagetian sense, misconceptions can result from deficiencies in mathematics curricula or from teaching strategies employed by teachers that do not give students opportunities to assimilate new concepts (Xiaobao &Yeping 2008). Others have indicated that misconceptions are a result of inconsistency in students’ solutions to mathematical problems (Brown & Burton

1978). While Mack (1990) argued that students' misconceptions are linked to their knowledge of fraction symbols and algorithmic procedures.

Learning Theories and Misconceptions

As we know, our students often make mistakes in mathematics and in other subjects; the learning of mathematics certainly produces errors. The question is why they are making mistakes. What are the reasons behind them? What we have to do as educators to help our students to overcome or avoid mistakes in our topics? In order to answer all of these questions we have to interpret or justify these mistakes in terms of a learning theory (Olivier 1989). The learning theory we adopt in interpreting students' misconceptions in mathematics will decide the importance of these misconceptions for students' learning. Moreover, the theory will clarify the role of these misconceptions in students' learning.

In the 20th century, there was a radical shift in how the learning theories viewed human learning. In the first half of the century, Thorndike and Watson's stimulus-response theories of human learning were dominant. In the second half of the century, other cognitive theories were dominant and focused on the importance of experience during the learning process (Idris 2005).

Many theories have appeared as a result of the great interest in students' learning and in discovering their mathematical difficulties and misconceptions. Two theories or schools of thought can be mentioned: the first theory focuses on the external behavior of learner and is called the behavior theory; the second theory is concerned with the learner's mental operations occurring in his mind and is known as the cognitive/ constructivism theory.

In the next section, learners' misconceptions about dividing fractions will be discussed from the two different perspectives of behaviouristic and constructivist positions.

Behaviourism Theory

This theory relies on the empirical philosophy of science that knowledge begins in experience. It assumes that knowledge can be transferred from one student to another. The learner in this theory is seen as a passive recipient learner or as a blank sheet on which teachers can write. According to this theory, prior knowledge influences leaning, and learners construct concepts from prior knowledge or experience. This knowledge caused difficulties for learners to change or modify learning (Mestre 2001). Moreover, the theory believes that the student can get knowledge directly from his/her experience and current knowledge is not necessary for learning to occur. Additionally, this theory considers learning as a conditional process, whereby a particular response is linked to a particular stimulus (Thorndike 1922, cited in Olivier 1989). This theory believes that the individual or learner is focused on accomplishing a well- identified objective or goal and consequently getting a prompt response to a well-defined problem (Olivier 1989). However, since this theory is stimulus-response based, in order to get the appropriate response, the appropriate stimulus has to continue; otherwise the expected or desired performance will not occur.

Since this theory assumes that new information is not related or isolated from the students' existing knowledge, the current students' concepts are needed for learning so that behaviorist theory perceives students' errors and misconceptions are not important and insignificant to the acquisition of new knowledge. Only correct knowledge or answers have importance for behaviouristic learning. Additionally, the theory sees misconceptions and errors as a faulty segment in the student's memory which can be erased or written over by informing the student the correct concept or procedures (Strike 1983 cited in Olivier 1989; Gagne 1983).

Constructivist Theory

The constructivist learning theory, which has its roots in Piaget's Cognitive Theory of Development, "emphasizes abstractions and reflection of knowledge as a continuum for learning mathematics"(Kopsovich 2001, p. 9). The theory believes in truth but not as one constructed by somebody. Additionally, the theory considers the learner as an active person constructing his/her knowledge and experience and the knowledge is rooted in his/her memory. Constructivist scholars (Piaget 1964) assume that students are not getting their mathematical concepts directly from experience, but individuals create them and their meaning exists within the framework of that individual's experience. However, the student's learning depends on the quality of ideas that he/she will bring to the experience, and on the interaction between experience and the student's current knowledge structure (Confrey 1991). Additionally, Piaget (1964) indicated that direct experience, cognitive conflict, and social interactions are factors that help the learner to construct his/her own knowledge.

Learning from a constructivist perspective, is regarded as an active process of interaction between the learner's experience and prior knowledge (Confrey 1991) and not by transmitting information. Constructivists consider mathematics as a human creation, developed gradually in a specific cultural context. Moreover, they believe that mathematical concepts are constructed through students' activities that allow them to construct experiences and perform mathematical problems. The student constructs the learning of mathematics personally in order to make sense or meaning out of his/her solutions. The constructivist theory considers learners as the architects who construct their knowledge, to find out the relationships, and to construct their own mathematical concepts. The theory informs us that learners understand relationally throughout their own construction of knowledge (Glaser 1990; Brown et al. 1989). Additionally, the theory implies that learners are willing to spend a significant effort in constructing their concepts or schemata that have meaning to them if they will use the gained knowledge effectively in suitable situations. According to this theory, students' learning is a cyclic process through phases of action. Therefore, if the learning occurred without this cycling sequence, the student learning will be disconnected or isolated from real world situations. Moreover, in order to examine a student's understanding of a mathematical concept, constructivists are looking for how a student approaches a particular mathematical problem.

The theory does not see the student as a passive recipient of knowledge from his environment, and the knowledge cannot be transferred ready- made from one student to another. Therefore, according to this perspective the student's existing knowledge interacts with the new knowledge that he/she acquires through instruction, i.e., the student builds new knowledge on his prior knowledge. In other words, students build new knowledge on existing knowledge is like a schema stored in student's memory that can be retrieved and used when it is needed. Moreover, learning according to this theory occurs if an interaction between student's schema and new ideas exists.

Thus, for the student to get or comprehend an idea, he needs to put or build the new idea into the correct or appropriate schema. The new information is organized and structured in the student's memory into appropriate schemas through assimilation, accommodation or distortion (Smith et al. 1993). However, in some cases new ideas or information might be different from any existing schema, so that it will be impossible for the student to link it with any available schema. Therefore, the student will try to create a new box in order to sort and memorize it, which will create an inappropriate cognitive structure, not linked with any existing schema, and will not be understood and difficult to remember. Therefore, unlinked knowledge is the source of any errors and misconception in mathematics when the student tries to retrieve or remember distorted rules or knowledge.

Constructivism stresses the importance of prior knowledge in the learning process. Students understand mathematical tasks and instructional activities according to their prior knowledge to allow the new knowledge to be part of the students' conceptual understandings (Ernest 1996; Herscovics & Linchevski 1994), and according to his/her learning styles. From a constructivist perspective misconceptions arise from students' prior knowledge, either in the classroom or from their interaction with the physical and social world occurring regularly caused by mental schemas that are not linked or inappropriate. Moreover, misconceptions are a characteristic of initial phases of learning because students' existing knowledge is not enough and supports only partial understandings (Smith et al. 1993). Additionally, misconceptions and errors are very important to the learning process and they are part of students' knowledge structure that will interact actively with the new knowledge and will negatively affect the new learning. Students' misconceptions are entirely legitimate for students and are seen as an alternative concept and are helpful for limited application. Moreover, this theory believes that as teachers we have to encourage our students to express their ideas in order to get insight into their perspectives in order to remediate their misconceptions.

Since mathematics misconceptions have been gained or acquired through constructivist activities, it is vital to employ the constructivist approach in reconstructing the mathematics concepts process with the desire of acquiring correct concepts, or schemata (Fast 1997). However, the constructivist theory has some weaknesses in that it is only, similar to progressive educational theories, successful with learners who come from rich families, have committed parents and have outstanding teachers. Students in constructivist classrooms are behind those in traditional classrooms in basic skills (Fast 1997; Glaser 1990). Additionally, this theory has a major weakness in that it provides no connection between its theoretical basis and what teachers should do in the classrooms.

Learning Style and Misconceptions Definitions

It is not easy to adopt or use a particular learning style definition. Each researcher provides his/her own definition for a variety of reasons. One of these reasons is that some researchers are interested in studying one aspect of the learning process, another reason is related to the availability of different learning styles inventories(about 71 inventories), and yet another is the different theoretical bases employed by researchers (Ozkan 2003). However, various definitions were mentioned in this chapter. James and Gardner (1995) define learning style as the "complex manner in which, and conditions under which, learners most efficiently and most effectively perceive, process, store, and recall what they are attempting to learn" (p. 20). Davidson (1990) and DeBello (1990) state that learning style refers to how individuals attain, process, and accumulate information. Felder and Henriques (1995) define learning style as the way in which an individual gets, maintains, and repossesses information. Furthermore, Vermunt (1998, 1996) describes a learning style as a model that consists of four dimensions: processing, regulating, mental learning models, and learning orientation. In the Vermunt definition, the mental models of learning refer to conceptions/misconceptions students have regarding the learning processes, which indicate the relationship between students' learning styles and having misconceptions in a specific task. Finally, Dunn (1990) defines learning style as "the way each learner begins to concentrate, process, and retain new and difficult information" (p. 224). Furthermore, she describes learning styles according to the learner's ability to master new and difficult knowledge. Since the Kolb's Learning Style Inventory will be used in this study as a data collection instrument, Kolb's (1985) definition of learning style as the method by which the learner receives, processes, acquires, and retains knowledge by accommodating, diverging, converging, and assimilating from his environment will be adopted.

With respect to misconceptions, the authors indicate that students come to school with many fraction concepts that are inconsistent with the correct fraction concepts and deficiencies in performing operations involving fractions. These inconsistency concepts are called alternative concepts or misconceptions. Researchers use the term "misconception" to describe and explain students' performance in specific subject-matter domains (Eaton et al. 1983; Gardner 1991; Shaughhnessy 1992 cited in Smith et al. 1993). Brown (1992) stated that the term "misconception" to refer to a "student's ideas which are incompatible with currently accepted scientific knowledge" (p.18). Jose (1989) and Resinick (1983) define the term as negative intrusion between student conceptions and learning when the student attempts to employ it in new situations. In this study, the definition used by Smith et al. (1993) - "student conception that produces systematic pattern errors" (p. 119)-will be used.

These systematic pattern errors can be defined as “a repeatedly occurring incorrect response that is evident in a specific algorithmic computation” (Cox 1975, p. 9) and the same error appears in at least 25% of the students for a specific concept or operation (Luneta. & Makonye 2010; Riccomini 2005).

Knowledge of Fractions

Although fractions are an essential and vital part of the middle years’ mathematics subjects, groundwork for the development of students’ proportional reasoning is necessary for future mathematical topics such as algebra and probability. Additionally, fractions are involved in many aspects of mathematics; for example, representing and controlling part-whole situations is necessary for measuring continuous quantities and comparing quantitative quantities (Pitkethly & Hunting 1996). Educational studies also have shown that many students face difficulties and low performance in mathematics in general and in fractions (Halat 2007, 2006; Ni 2001; Moss & Case 1999; Behr et al. 1984; Hiebert 1985; McLeod & Armstrong 1982). These difficulties in fractions are a worldwide phenomenon, including countries with high mathematics achievement, such as Japan, South Korea, and Singapore (Nunes & Bryant 2008; Stafylidou & Vosniadou 2004; Yoshida & Sawano 2002). Many factors cause these difficulties. Some of these factors are: learning styles (Sloan et al. 2002; Kolb 1984 cited in Kolb et al. 1999), instruction and different uses of assessment and evaluation techniques (Vinson 2001). Additionally, Li (2006) mentions other factors that might have an effect on students’ mathematics abilities such as uses of mathematics curricula, effects of the school environment, students’ thinking, teachers’ ways of teaching, students’ attitudes toward mathematics, and problems related to school management.

Misconceptions of Fractions

Even though the various interpretations of fractions can create misconceptions, different features or aspects of fractions can be explored, such as proper and improper fractions, mixed numbers, the four operations on fractions; addition, subtraction, multiplication and division, fraction equivalence, and comparing of fractions. Furthermore, according to Lamon (2001) other mathematical concepts are connected to the meaning of fractions, such as geometry, number-line, and multiplying and dividing whole numbers.

The phenomena of misconceptions in fractions have been investigated widely by researchers, especially those who are interested in mathematics and science education, as well as many educators and psychologists, such as Bruner, Ausbel, Novak, Tyler, and others (Ennenbach 1983). According to many researchers (e.g., National Research Council (NRC) 2001; Baroody & Coslick 1998; Mack 1993), students come to school with different types of misconceptions in mathematics in general and in fractions in poarticular. Schechter (2006) points out that even a student at the college level shows misconceptions that come from lower classes such as adding, subtracting, multiplying, and dividing of fractions. Moreover, students who have mastered these previous concepts and skills are unable to employ them in new topics or situations (Keazer 2004). Misconceptions linked to dividing and multiplying fractions have an effect on students' capability in solving problems in other mathematical areas, such as algebra (Brown & Quinn 2007).

Students' misconceptions about fractions are the source of students' difficulties in mathematics through calculus. Some of these difficulties arise due to their whole-number knowledge. For instance, the fraction $\frac{3}{5}$ can be viewed by students as two different whole numbers. Furthermore, some students consider the fraction $\frac{1}{5}$ to be bigger than $\frac{1}{3}$ since **5** is larger than **3** (Baroody & Coslick 1998; Behr et al. 1992). Steffe (2004) states that some students might show difficulties in comprehending that the numerator and denominator of a fraction have a multiplicative relationship rather than an additive one, which is very important in simplifying and commensurate fractions. Other misconceptions occur because fractions give different meanings or the fraction concept is not defined clearly; for example, the fraction $\frac{1}{4}$ of a chocolate bar indicates part of a whole, whereas, in the case of three students out of four, the fraction indicates a part of a set.

A substantial number of research studies (Kouba et al., 1988; Kerslake 1986; Behr et al. 1983, 1984, 1985; Carpenter et al. 1981) have focused on studying students' misconceptions on fractions. The results of these studies highlighted various categories of misconceptions and the reasons behind them. Holding misconceptions in mathematics in general and on fractions specifically can result from different causes. Some of these reasons, as mentioned by Brownell et al. (2005), are the quality of instruction or prior inadequate teaching, informal thinking, and poor performance. Other reasons mentioned by many studies (e.g. Baroody & Hume 1991; Kelly et al.

1990; Jencks et al. 1980) include the fact that students' misconceptions may result from confusing algorithms or employing algorithms incorrectly.

Furthermore, the National Research Council (NRC 2001) indicated that helping students to learn fractions with their own approaches and helping them link the fraction concepts and procedures to solve problems would minimize the incidence of misconceptions about fractions. It will also help them in employing these concepts to new ideas and in real-life situations that enable them to perform operations on fractions successfully (Leinhardt 1988; Gunderson & Gunderson 1957). In addition, Streefland (1991) acknowledged that it is necessary for students to construct their own understanding of fractions and the procedures they use in performing fractions' operations. Stipek et al. (1998) state that focusing on how students learn is a factor in improving students' performance in fractions and that they become more interested in solving problems involving fractions.

Using and understanding fractions and their applications are considered basic mathematical skills needed by all students at different academic levels and by all participating members of society (Markey et al. 2003). Many researchers (e.g., Tzur 2004; Bulgar 2003; Mack 1990, 1995) have indicated that there is reason to believe there is a link between how students learn and understand fractions and held misconceptions and that their understanding and ability to solve fractional problems improves when students create and use their own learning styles or approaches and their solutions. These beliefs come from the fact that there is a connection between held misconceptions and achievement and a relationship between how students learn and comprehend fractions and achievement. Thus, by using the transitive property in mathematics, I can hypothesize that a relationship might exist between students' learning styles and held misconceptions about fractions. Considering the importance of finding a connection or a link between students' learning styles and held misconceptions about fractions, this study will investigate such a relationship to gain a better understanding of this connection to focus our efforts as educators on students' learning in future efforts to help them to overcome these deficiencies or misconceptions.

Fractions were chosen in this study because they are considered an ideal topic (Niemi 1996) for investigating students' misconceptions in grades five and six. Furthermore, fractions are a vital topic of elementary students, and many studies (Lamon 1999, 2001; Niemi 1996) have indicated that students around the world in general and in UAE in particular face difficulties in comprehending and performing fractions and basic skills (Trends in International Mathematics and Science Study [TIMSS] 2011, OECD 2010; 2007).

Dividing Fractions

Fractions are an important topic in the number system. For instance, to find an integer number answer for a simple division problem such as $4 \div 5$ without fractions is not an easy process and the multiplicative inverse of integer numbers would not exist for the set of whole numbers (Hunting et al. 1996; Mack 1995; Behr et al. 1992).

According to Tirosh (2000, p. 9) the “division of fractions is often considered the most mechanical and least understood topic in elementary school,” and students’ performance in solving problems involving division of fractions is very poor. Tirosh also states that students’ errors in dividing fractions are algorithmic, intuitive, and based on incorrect formal knowledge. She indicates that division of fractions is an example of a concept where students and teachers deal with matters procedurally without understanding them conceptually. Dividing and multiplying fractions are difficult for students to grasp because students start computations before they obtain suitable knowledge of such operations (Aksu 1997) and because the division idea is different from what students are used to in multiplying and dividing whole numbers. When a student multiplies fractions, the answer will be smaller, not bigger as they expect. In addition, in dividing fractions, the case is the opposite compared to whole-number division. When the student divides two fractions, the answer is larger, not smaller as in the case of whole numbers (Sharp & Adams 2002). Along with that, Hart (1981) stated that students in dividing fractions believe that the dividend should be larger than the divisor. This belief might cause an error in solving such a problem $\left(\frac{1}{4} \div \frac{1}{2}\right)$ should be written as $\left(\frac{1}{2} \div \frac{1}{4} = 2\right)$ or from inadequate formal knowledge (Tirosh 2000) that division is commutative and $\left(\frac{1}{4} \div \frac{1}{2} = \frac{1}{2} \div \frac{1}{4} = 2\right)$.

In dividing two fractions such as- what is $\frac{1}{3}$ divided by $\frac{1}{9}$?- in order to solve such problems, the students employ the invert- and-multiply method which is easy to memorize and quickly forgotten and difficult for them to comprehend. Therefore, the student will answer it as follows: $\left(\frac{1}{3} \div \frac{1}{9} = \frac{1}{3} \times \frac{9}{1} = \frac{9}{3} = 3\right)$

The previous problem should be explained and solved as:

How many $\frac{1}{3}$s in a $\frac{1}{9}$?

$\left(\frac{1}{3} \div \frac{1}{9} = \frac{3}{9} \div \frac{1}{9} = \frac{3}{1} = 3\right)$ (Which means that there is 3 ninths in a third)

Rizvi and Lawson (2007) mention other issues that make division of fractions difficult for students. The first issue is that teachers introduce the division concept to their students based on the idea of fair-sharing; for example, $(24 \div 3)$ is introduced to students as sharing 24 pencils between 3 students. The other issue is linked to the fact that teachers introduce the division of fractions as repeated subtraction. According to this approach, the problem $(24 \div 3)$ is introduced to students as "how many times **3** can be subtracted from 24." Using this approach makes students unable to solve a fraction division problem, especially if the divisor is larger than the dividend; for example, in the problem $\left(\frac{1}{5} \div \frac{1}{3}\right)$, it will be difficult for students to ask how many times one-third can be subtracted from one-fifth.

Dividing fractions requires that students master various skills. Some of these skills are related to whole-number knowledge and how to multiply and divide them. Other skills are linked to students' understanding of fractional concepts, such as mixed numbers, improper fractions, equivalent fractions, how to convert from mixed numbers to improper fractions and vice versa, and how to write the answer in lowest terms.

In solving problems involving fractional operations, students tend to import procedures and algorithms that might be correct for other operations and incorrect for the operation that is needed to solve the problem. According to Siegler et al. (2011), most mistakes in performing fraction operations occur in multiplication and division. These mistakes occur because students import the procedure of common denominators in the addition and subtraction operations and then multiply the numerators or divide them, and they leave the denominator unchanged. For example, in solving the problem $\left(\frac{2}{3} \times \frac{1}{5}\right)$, the students will give the answer $\frac{30}{15}$. They get this answer by determining the common denominators for both fractions $\left(\frac{10}{15}, \frac{3}{15}\right)$ and then they multiply the numerators. However, Sharp and Adams (2002) argued that using this algorithm in solving a fraction division problem builds more naturally on students' knowledge of dividing whole numbers. In other cases, to solve a division problem, students employ the inverted algorithms, but instead of inverting the second fraction and multiplying, they invert the first fraction. According to Sharp and Adams (2002), using the inverted algorithm in solving a fraction division problem is an "isolated activity from concepts and meanings" (p. 336).

Based on the previous paragraphs, dividing fractions is the most complex of the mathematical operations and many students face difficulties and make misconceptions about dividing fractions (Ma 1999). Therefore, it is very important to find methods or approaches to help students overcome these difficulties and minimize the number of misconceptions that exist in students' mathematical knowledge. Additionally, teachers should instruct the division of fractions within appropriate context that is not in conflict or does not contradict with students' constructed knowledge about division.

Other researchers (Hart 1981) mention that students might consider division of fractions is commutative based on their idea that $\left(1 \div \frac{1}{3} = \frac{1}{3}\right)$ because $\left(1 \div \frac{1}{3} = \frac{1}{3} \div 1 = \frac{1}{3}\right)$.

Teachers' knowledge of different error sources would help them in discovering both the source of student errors and a suitable instruction approaches and methods for supporting students that are struggling to make sense of mathematical concepts in order to help them in overcoming their errors.

As mentioned above, there are different origins for students' errors in dividing fractions; however, none of the studies tried to investigate if the student's learning style might cause an error. So that, by identifying students' learning styles and finding out their misconceptions on dividing fractions, it is possible to investigate if there is a relationship between held misconceptions and learning styles and this will help the two grades' students to avoid difficulties and misconceptions about dividing fractions. For example, introducing the division of fractions by lecturing students who are described as auditory learners can aid them in comprehending and performing problems involving fractions. Using the same approach with a kinesthetic learner who depends on hands-on activities in learning might impede their learning and caused some misconceptions.

Most previous studies dealt with students’ difficulties and misconceptions about fractions and none of them tried to find out if there is a relationship between students’ learning preferences and held misconceptions in dividing fractions. Therefore, this study tried to find out if how students learn mathematics is a source of errors in dividing fractions, and as teachers what approach we have to use in our instruction to employ teaching methods that match our students’ learning styles.

In this chapter, an introduction to students’ difficulties and misconceptions in dividing fractions were presented. Learning styles models that been used in many similar studies were documented. Reasons for selecting Kolb’s model as a theoretical framework instead of other models were explained and justified. Different perspective of learning theories that clarify or studied misconceptions were mentioned. Moreover, I have tried to clarify that there are different reasons behind students’ errors in fractions in general and in dividing fractions in particular.

In the next chapter (Chapter 3), the processes that have been used in collecting the data, data collection instrument designs, research design, sample selection, the pilot study that was conducted to maintain technical qualities for both data collection instruments and data analysis will be described in detail.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

This chapter will discuss the research methodology implemented in this study, research design, data collection instruments, pilot study, sampling techniques used in selecting the study participants, and the data analysis methods.

Research Design

The research design is the outline of any study since it will help in facilitating various research aspects. Furthermore, it will guide the researcher in arranging the type of method to be employed for collecting suitable data and determining the appropriate data analysis techniques. The research questions, description of the research problem, and the aims of the study are considered key factors in selecting the appropriate research design or paradigm (Schoenfeld 2002).

This study adopts the quantitative approach since the data were collected from a mathematics diagnostic test, and Kolb's learning style inventory. The differentiation between quantitative and qualitative approaches is based upon various philosophical assumptions and not apparently on the type of collected data (Creswell 2005). Researchers and educators mention different definitions for quantitative research. According to Creswell (1994), quantitative research is a type of research that explains phenomena by collecting numbers that can be analyzed by using statistics and implementing the right data analysis instrument. Additionally, quantitative research is designed to be separated from a particular situation under study such as academic department and classroom.

Since the truth or reality of the studied phenomena is to find out if there is a relationship between held misconceptions and learning styles; and the number of participants is large, quantitative research will be the choice to answer the research questions and test the research hypotheses. A quantitative correlation design is appropriate because it enables the researcher to determine whether there is a negative or positive relationship and how strong it is, as well as, to clarify the nature and type of the relationship between two or more variables in the real world. Moreover, it will give the opportunity to generalize the results or conclusions over the study population and it is considered more reliable and statistically significant.

Procedures and Analysis of Pilot Study

The aim of the pilot study was to check the psychometric properties (reliability and validity) of the two data collection instruments (Arabic versions) in a sample of 250 students in grades five and six from three different schools. Specifically, the analysis below examined the internal consistency, reliability, and the validity of the two data collection instruments.

Data Collection Instrument Reliability and Validity

The main purpose of reliability is to ensure the consistency of the data collection instrument in relation to what it is going to be measured or is supposed to be measured. Therefore, after the translation of both Kolb's Learning Style Inventory and the mathematics diagnostic test into Arabic by the researcher according to the procedures mentioned in the next section, a pilot study was conducted on a sample of 250 students selected from three different schools from the study's population as mentioned in details bellow.

A total of 250 students were involved in the pilot study fitting into two grades: 138 students in grade six and 112 students in grade five. The sample consisted of 138(55.2 %) males and 112 (44.8 %) females as shown in Table 5.

Table 5: The distribution of students according to school, gender, and grade

School Name	Frequency	Gender	Grade
School A	68	Male	Six
School B	70	Male	Six
School C	112	Female	Five
Total	250		

Learning Style Inventory (Appendix-A) Reliability Results

The Learning Style Inventory (LSI-3.1) (Appendix-B) consists of twelve short statements related to learning situations that the participants were asked to rank four learning preferences. After adding each of the four columns, a total score of each of the four learning scales (Concrete Experience- CE, Reflective Observation-RO, Abstract Conceptualization- AC, and Active Experimentation- AE) was obtained for each participant. The differences between AC / CE and AE/RO will address four learning styles preferences: convergent, divergent, assimilative, and accommodative respectively. The row data for the four learning cycles will range from 12 to 48. A higher value or score is an indicator of a specific learning approach.

The Arabic version of Kolb's Learning Style Inventory version 3.1, which was translated by the researcher, is used to determine the learning styles of both grade five and six students. Kolb and his associates (2005) confirm that the LSI has maintained the Alpha reliabilities ranging from 0.81 to 0.88 compared to the Alpha values for the Arabic version that ranged from 0.79 to 0.84 Alphas shown in Table 6. Alpha reliabilities for the Arabic version were computed by using Cronbach's Alpha formula.

Table 6: A comparison between the Kolb's LSI and the Arabic version with respect to reliabilities

Construct	Cronbach's Alpha Coefficient Reliability of Kolb's LSI	Cronbach's Alpha Coefficient Reliability of Arabic version of Kolb's LSI
Concrete Experience (CE)	0.82	0.82
Reflective Observation (RO)	0.81	0.81
Abstract Conceptualization (AC)	0.83	0.80
Active Experimentation (AE)	0.87	0.79
AC-CE	0.83	0.84
AE-RO	0.88	0.81

The instrument is deemed reliable since the coefficient Alpha reliabilities for the four basic scales of CE, RO, AC, and AE and the two differences AC-CE, and AE-RO show good internal reliability and are very close to values mentioned by Kolb and his associates in Table-2. These reliabilities ranged from 0.79 to 0.84.

Learning Style Inventory Validity Results

According to Ary et al. (1996), an instrument is considered valid if it measures what it is supposed to measure. Validity is classified into three categories: content, criterion-related, and construct validity. The first and the third categories show how the instrument content measures the settings of collected results (Isaac& Michael 1995). This type of validity has been achieved in the LSI through different studies conducted in various disciplines of Kolb (1976, 1981) and studies of Smith and Kolb (1986).

The inventory has been translated into the Arabic language by the researcher and has been given to three English teachers (Bilingual- speaking Arabic and English) to make sure that there are no mistakes or misleading words in the translation. Additionally, the translated inventory was given to two education experts to check its wordings and its suitability to students' reading level. The reviewer put some comments that are related to three items that needed to be reworded; their comments were taken into consideration in the final version of the inventory.

Mathematics Diagnostic Test (Two versions) (Appendices C&D)

The test is designed to determine students' misconceptions and errors in dividing fractions. In order to develop a test that has the ability to achieve the study's aims, the researcher started the process by identifying the following types of division problems: dividing two mixed fractions, dividing two proper fractions, and dividing fractions by a whole number. Additionally, the researcher, based on the two grades' curricula description and textbooks, tried to determine the steps needed to divide two fractions in order to choose the test items' distracters according to these steps. All items' distracters were carefully written to reveal possible errors and misconceptions in dividing fractions. Moreover, the test items consist of questions ranging from concepts to performing division problems. Some items were designed to extract computational understanding or needed skills by the student. Additionally, graphics were used to find out if the student can read or interpret the figure to solve a fractional problem.

According to ADEC (2010, p. 20, 23), the students in grades five and six should operate competently with numbers of any size and with fractions. To determine students' misconceptions about dividing fractions, a mathematics diagnostic test was designed by the researcher that has the ability to achieve that purpose. The test in its final version contains twenty questions and takes twenty-five minutes to complete. The first section contains fifteen multiple-choice conceptual questions and section two contains five fractions division problems. The students will use paper and pencils; calculators will not be permitted during any part of this test.

Mathematics Test Reliability Index

All students' responses on the test participating in the pilot study were corrected and scored. The students' responses were divided into two sets of data in order to find the test reliability index by using the Spearman-Brown split half coefficient, which yielded a value of $r = 0.91$. This value indicates that the test is highly reliable and is stable over time.

Mathematics Test Validity

The test was given to different reviewers of different backgrounds to give their comments on the test with regards to the following aspects; its ability to determine whether the test is able to identify students' errors and misconceptions on dividing fractions. Whether it is able to measure what it is supposed to do, the test questions' language and vocabulary, mathematical concepts in the test, reading level and its suitability for grades five and six. Also, the reviewing process will determine if all concepts or content mentioned on the test were given to students and included in the curricula, clarity of instructions, and effectiveness of distracters. The test was given to four mathematic teachers teaching grades five and six for more than five years, three mathematics education experts, a measurement and statistics specialist and three mathematics professors. Their feedback and comments on the test were considered and the test modified according to that for its final shape.

The Main Study

Study Sample and Context

The United Arab Emirates (UAE) is located in the Middle East bordered by Oman, Saudi Arabia, Qatar, and Arabian Gulf. According to UAE National Bureau of Statistics (2010), the population of UAE has reached 8.3 million people; 2.5 million of them live in Abu Dhabi the capital of UAE. About 89% of UAE population is expatriates. Therefore, the culture of Abu Dhabi is a mixture of a number of world cultures. However, as an Arabic country, Abu Dhabi culture is rooted in Arabian's Islamic traditions and thoroughly inculcated with Arab-Islamic values (Richardson 2004). Also, it is home of several multi-ethnic communities that live peacefully. Since Islam is the religion of the UAE, the holy Koran asserts on the importance of education and getting knowledge from different resources. Additional, Islam declares that education is the right of male and female and no segregation according to gender. Women as well as men in UAE are encouraged to go to schools, colleges and universities, and the UAE government trying to shift from quantity to quality in education (Rodenbeck 2003), employing more Emiratis and less dependent on expatriates. Along with that, The UAE government provides education for its citizens of free education for all nationals from K-12 to university (Godwin 2006).

Research in mathematics education in UAE was, and still, limited. Research in students' errors in mathematics in general and in fractions in particular is lacking. Research in students' learning preferences is almost non-existent. However, many efforts are in place in order to improve students' performance in mathematics. Connecting to the limited mathematics education studies that investigated the relationship between students' misconceptions in fractions and their learning styles conducted in UAE encouraged me to conduct this study to fill the gap in the education literature about UAE schools in order to help UAE policy makers, curricula planers, and ADEC to include students' deficiencies in fractions' on their agenda.

The Abu Dhabi Educational System consists of two sectors: public and private. It is divided into four cycles or stages. The kindergarten stage provides education to students four to five years of age. The primary stage or Cycle 1 (grades 1-5) provides education for students from six to twelve years of age. In the preparatory stage or Cycle 2, (grades 6-9), education is provided to students from twelve to fifteen years of age. Finally, in the secondary stage or Cycle 3, (grades 10-12), education is provided to students aged above 15 years old and consists of three levels (Abu Dhabi Education Council [ADEC] 2010).

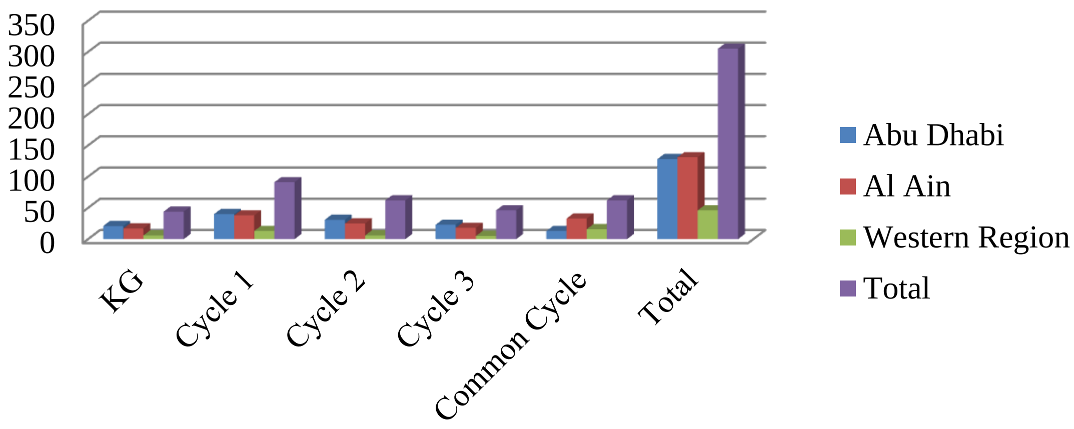
According to ADEC (2011), there are 305 schools distributed into three educational zones as illustrated in Table 7, and Figure 2.

Table 7: Distribution of Abu Dhabi public schools according to educational zone, number of schools, and cycle

Educational Zone	KG	Cycle 1	Cycle 2	Cycle 3	Common Cycle	Total
Abu Dhabi	21	40	31	23	13	128
Al Ain	17	38	25	18	33	131
Western Region	6	13	6	5	16	46
Total	44	91	62	46	62	305

(ADEC 2011, pp. 24-38)

Figure 2: Distribution of Abu Dhabi public schools according to educational zone, number of schools, and cycle



The population of this study includes students in the fifth and sixth grades in Abu Dhabi public schools (N= 9,602 students), 4,688 students in Grade five and 4,914 students in Grade six from 71 public schools and 381 classes distributed according to cycle and gender, as illustrated in Table 8 and Figure 3 . Abu Dhabi Education Council (ADEC) segregates government schools according to gender from grade six and above. In some schools (very limited number) grade five classes have both male and female students. Also, 95% to 97% students in Abu Dhabi government schools are Emiratis and the rest are expatriates. Therefor the segregation occurred only according to gender and we can assume that the sample is homogenies in terms of culture, ethnicity.   According to Dumay and Dupriiez, (2008; p. 541) “segregation is seen as unequal distribution of students between schools, according to some characteristics: sex, ethnicity, academic and sociocultural backgrounds…”

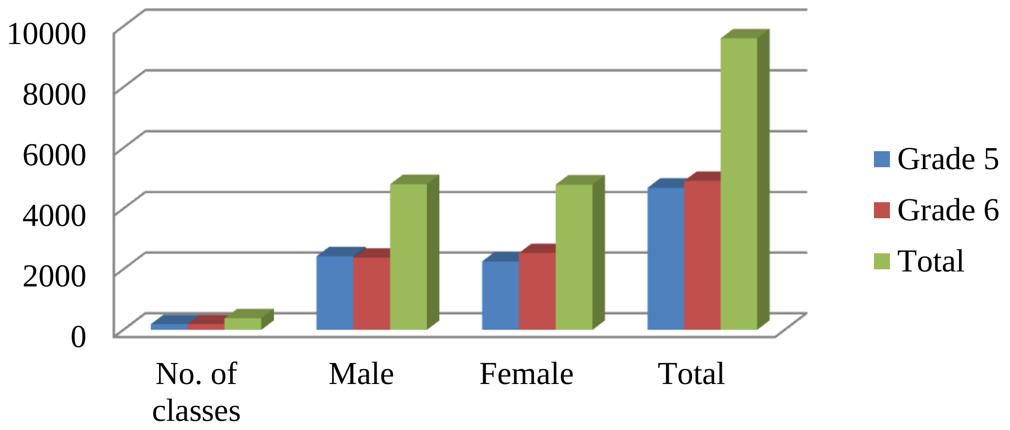
The reason they were chosen is that the fraction topic starts in grade five and continues in grade six; additionally, fractions are considered a large part of the middle school curriculum and the two grades are exposed to different fraction interpretations and representations. Furthermore, fractions are an essential part of the mathematics curriculum in primary schools around the world in general (Charalambous et al. 2010; Panaoura et al. 2009) and in the UAE in particular.

Table 8: Distribution of the population according to grade, gender, and number of classes

Grade	No. of classes	Male	Female	Total
Grade 5	191	2428(51.79%)	2260(48.21%)	4688(48.82%)
Grade 6	190	2380(48.43%)	2534(51.57%)	4914(51.18%)
Total	381	4808(50.07%)	4794(49.93%)	9602(100%)

(ADEC 2010, pp. 24-38)

Figure 3: Distribution of the study population according to grade, gender, and number of classes



Conducting this study with all fifth- and sixth- grade students in Abu Dhabi public schools is not possible due to the lack of time and resources and to avoid interfering with the normal school setting. Therefore, a representative and efficient sample that uses clusters (schools) rather than single-unit elements (students) and are randomly selected was employed and have the same characteristics of the population (Johnson 2003).

Due to the fact that complete randomization was impossible, and since Abu Dhabi is the largest emirate in UAE, and the number of schools in Abu Dhabi that include the two cycles one and two (71 schools) constructs approximately half of the total number of schools that belongs to ADEC (153 schools) and have the two cycles. Additionally, by assuming that Abu Dhabi schools are considered a representative sample of UAE schools, this study was conducted only on schools belonging to the Abu Dhabi Educational Zone. Seventy-one schools have grades five and six with 381 classes and 9,602 students. The schools were given random numbers from 1 to 71; every fifth school was selected which will give a total number of 15 schools as can be seen in Tables 9, 10 and 11 and Figures 4 and 5 with approximately 1,864 students .

The sample consists of 978 female students (52.5%) and 886 male students (47.5%) distributed according to the two grades as 925 students in grade five (49.62 %) and 939 students in grade 6 (50.38 %). All grades five and six students in the selected schools were asked to participate in the study.

Table 9: Distribution of the sample according to gender

S. #.	School Name	Gender		Total
		Female	Male	
1	School D	0	102	102
2	School E	101	0	101
3	School F	199	0	199
4	School G	0	90	90
5	School H	152	0	152
6	School I	130	0	130
7	School J	0	133	133
8	School K	0	128	128
9	School L	124	0	124
10	School M	0	150	150
11	School N	84	0	84
12	School O	109	0	109
13	School P	0	107	107
14	School Q	0	116	116
15	School R	79	60	139
Total		978	886	1864

(ADEC 2010)

Table 10: Distribution of the sample according to the gender

Gender	Frequency	Percent
Female	978	52.5
Male	886	47.5
Total	1864	100.0

Table 11: Distribution of the sample according to the grade

Grade	Frequency	Percent
Grade Five	925	49.62
Grade Six	939	50.38
Total	1864	100.0

Figure 4: Distribution of the sample according to school name and gender

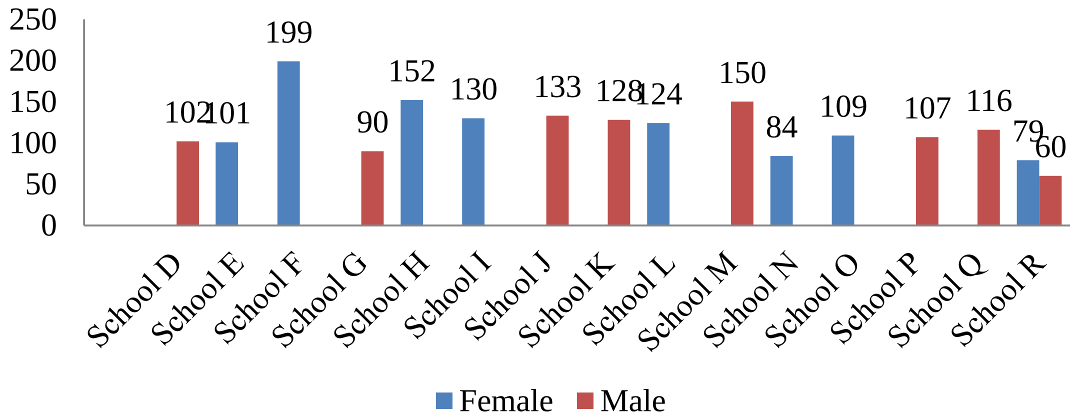
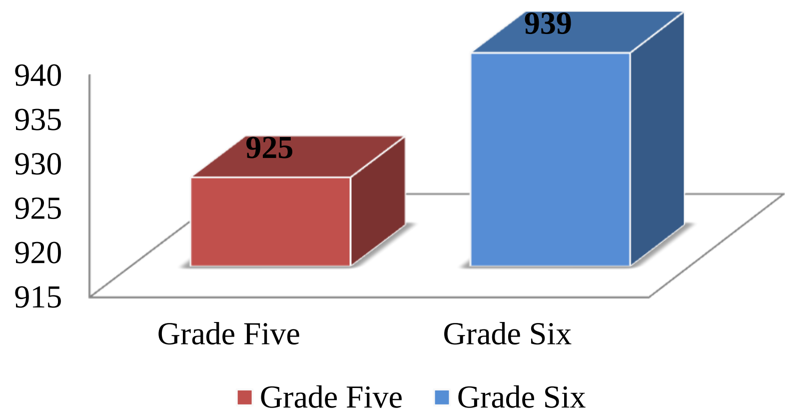


Figure 5: Distribution of the sample according to the grade



Data Collection Instruments

1) Learning Style Inventory (LSI) version 3.1 by Kolb (2005) (Appendix B)

To select the appropriate data collection instrument that has the ability to reveal students' learning styles accurately, different factors have to be taken into consideration. According to James and Gardner (1995, p. 22), three factors are important in the selection process: "the intended use of the data that will be collected, the matching between the data collected and the data instrument, and finally, other factors such as the instrument's validity , reliability, administration obstacles, and cost.” Therefore, the LSI version 3.1, developed by Kolb (2005), was used after it was translated by the researcher into Arabic to determine students’ learning styles. It was selected because it was created based on the experimental learning theory of Dewey, Lewin, and Piaget (Kolb 1984). Before administering the Arabic inventory, all technical qualities, such as reliability and validity indices, were maintained and documented as mentioned on the pilot study section.

The inventory consists of four basic categories or modes of learning with twelve incomplete statements, each of them having four possible completion phrases. These completion phrases are directly correlated with the four learning cycles or quadrant poles: convergent, divergent, assimilation, and accommodation. The row data for the four learning styles will range from 12 to 48. A higher value or score is an indicator of a specific learning approach. To find the preferred learning style for a specific student, the scores on the four categories will be combined. According to Matthews (1996, p. 252) and based on the LSI manual, the following formula was used to identify exactly student’s learning style. This formula is as follows:

> Abstract Conceptualization (AC) minus Concrete Experience (CE) and Active Experimentation (AE) minus Reflective Observation (RO) provide two combination scores ranging from +36 to -36. Plotting the combination scores on a grid and identifying the quadrant where the two scores intersect, one can determine a specific learning style from among the four styles: Diverger, Assimilator, Converger, and Accommodator.

Using Kolb’s model and plotting the two scores, we can identify the quadrant where the two scores intersect to identify the student’s learning style (Matthews 1996).

2) Mathematics Diagnostic Test (Appendix D)

According to ADEC (2007), the students in grade five and six should operate competently with numbers of any size and with fractions.

To determine students’ misconceptions on dividing fractions, a mathematics diagnostic paper and pencil test was developed by the researcher that has the ability to achieve that purpose. The test consisted of twenty questions and takes twenty-five minutes to complete. The first Section contains fifteen conceptual questions, and section two contains five fractions’ division problems. The first section of the test covers the following components: understanding of the fraction concepts, comparing fractions, equivalent fractions, representation of a fraction on the number line, lowest terms, improper and mixed fractions. Section two of the test consists of five fractions' division problems. It covers the following components: dividing whole numbers by a fraction, dividing two proper fractions, and dividing a fraction by a whole number. The students used paper and pencils, and calculators were not permitted during any part of the test.

Administration of both Data Collection Instruments

In order to administer the two data collection instruments in the selected school, an approval from ADEC was acquired (Appendix E). Meetings with school principals and mathematics teachers were arranged in order to get their approval to conduct the study in their schools based on ADEC approval and to choose a suitable day to do so. The data was collected from the selected schools with the help of mathematics teachers in the mathematics period during the last week of April and the whole month of May 2012.

Before the students started solving the mathematics test, the tests' instructions and purpose were explained to them. On average, the students finished the test within 25 minutes, however, those who could not finish within the time were asked to submit the test at the end of the mathematics period.

In order to minimize the interference or disturbance of the regular day of the selected schools and after they finish solving the test, in the same day and in the same period, the instructions for responding to the Learning style Inventory were clarified to the whole class or individually if it is needed. On average, all students finish answering the inventory in the allocated time (10 minutes).

By the end of the period, I informed the students again that their responses on both data collection instruments will be kept securely and will be used only for the purpose of the study and will not be used under any circumstances to assess their performance in mathematics.

Data Analysis

In order to answer the first question of the study that aimed at identifying the learning styles of the fifth- and sixth- grade students, the scores on the four categories (CE, RO, AC, & AE) were calculated. After finding the sum of each of the four columns (categories) in the LSI, a total score of each of the four learning scales was obtained for each participant. The differences between: AC / CE, and AE/ RO address four learning styles preferences: convergent, divergent, assimilative, and accommodative respectively according to the equation proposed by Matthews (1996) and the LSI manual mentioned earlier.

After each student had had their learning styles identified, a frequency tables with proportions of each learning style in each grade was computed in order to find out the number of students in each of the four learning styles. To check if there was a difference in learning styles between students in each class (the second research question), the Chi-square (χ^2) independence test was employed.

To answer the third research question that aimed at finding out types of misconceptions grades five and six hold in dividing fractions, a frequency table with percentages for each error was constructed by using SPSS version 17. The percentage of each error was calculated; if the error was repeated in 25% or more of all students' errors, it will be considered a misconception, as reported by Cox (1975). To categorize students' misconceptions about dividing fractions, each incorrect step procedure, operation, or answer was classified according to the classification mentioned by Newton (2008), as demonstrated in Table 12. This classification is selected because it covers all possible errors that students might commit in performing fractional problem. Students' misconceptions were divided into two groups according to the student's grade. A frequency table with percentages to show the number of students who have the same type of misconceptions was constructed..

Table 12: Errors classification

S.#	Error type
1	Multiply without flipping
2	Whole-number errors
3	Errors in changing forms(errors in writing the answer in lowest form)
4	Left blank
5	Knowledge of basic fractions concepts errors
6	Added or subtracted numerators or denominators
7	Flipped dividend
8	Cross-multiplied
9	Flip the dividend and the divisor
10	Miscellaneous

(Newton 2008, p. 1100)

The proportion test was used to answer the fourth question of the study that aimed at finding differences, if any, which that exist in dividing fractions' misconceptions among the students. The Chi-square $\left(\chi^2\right)$ independence test was performed and interpreted to answer the fifth question that aimed at determining if there is a relationship between students' learning styles and held misconceptions. Finally, to find if the difference, if any, exist between fifth and sixth grades' students learning styles and the type of misconceptions, a descriptive statistics was employed.

Ethical Considerations

Several ethical issues arose during this study. According to Cohen and his colleagues (2000), it is the right of the study participants to take part in the study or withdraw at any time. First, I received a letter from BUID (Appendix F) declaring that I have to collect my dissertation data from Abu Dhabi schools. Based on that letter, an approval to conduct the study from ADEC was gained. Before administering the two data collecting instruments in the selected schools, all schools were visited in order to brief them about the purpose and nature of the study and to obtain their approval to conduct; a suitable time was also selected with the help of mathematics teachers to collect the data during the mathematics periods. All the study participants' guardians were asked to sign a consent form (Appendices G & H) to confirm their permission to let their children participate in the study. Each student will be kept anonymous; all information gathered from the participants will be kept confidential. Only the researcher and the advising committee will have access to the datasets. Furthermore, the standards to protect the anonymity, confidentiality, and rights of the participants will be reviewed by the Ethical Review Board (ERB) at BUID (Appendix I).

Chapter 3 illustrated the methodology of conducting this study. The reasons for employing quantitative approach were mentioned. Moreover, sampling technique that been used in selecting the participants were described.

Steps that have been employed to maintain the technical qualities of the data collection instrument were discussed in details. These steps including reliability and validity indexes. Moreover, the steps of developing the mathematics diagnostic test and the translations processes into Arabic for both data collection instruments were clarified. Along with that, the data analysis that will be carried out to answer the study's research questions was mentioned.

In Chapter four, data analysis that was gathered in order to answer the study’s questions will be presented and interpreted in detail. It also contains the main results of this study according to the three questions that directed this study. The results will be reported by answering the study’s questions one-by-one.

CHAPTER IV

RESULTS AND DISCUSSION

In this chapter, the gathered data was analyzed and interpreted. Additionally, the study questions were mentioned and then their answers were presented one by one in order to make the results easy to follow and to guide the discussion through the whole chapter.

Research Questions

This study was conducted to answer the following questions:

1) What learning styles do the fifth and sixth grade students have when they learn fractions?
2) What differences, if any, exist in learning styles preferences between fifth and sixth grades' students?
3) What types of misconceptions about dividing fractions do students of grade five and six hold?
4) What differences, if any, exist in misconceptions about dividing fractions between fifth and sixth grades' students?
5) What is the relationship between students' learning styles based on Kolb's (1985) model and their misconceptions about dividing fractions?
6) What difference, if any, exist between fifth and sixth grades' students learning styles and the type of fraction misconceptions?

Research Question 1

What learning styles do the fifth and sixth grade students have when they learn fractions?

In order to answer this research question, a total score of each of the four learning dimensions were calculated according to the responses to the twelve items on the Kolb's learning style inventory. The differences between AC/CE and AE/RO with row scores ranging from -36 to 36 will address four learning styles preferences: convergent, divergent, assimilative, and accommodative respectively. The descriptive statistics for the four learning scales were calculated as seen in Table 13. The average score for the first dimension perceiving (the vertical axis) for AC-CE is (-2.75), and the average score for the vertical axis (processing) AE-RO is (-2.75). The average score for the horizontal axis and the score of the vertical axis are both negative, which indicated that the total survey students were located in the third quadrant (Converging). So that and according to Kolb's LSI, most of the participants were convergent learners.

Table 13: The averages of the four learning styles

Learning Scale	N	Average
Concrete Experience –CE	1864	31.56
Reflective Observation- RO	1864	31.08
Abstract Conceptualization -AC	1864	28.99
Active Experimentation –AE	1864	28.32
Total	1864	

As can be seen in Table 14 and, Figures 6 and 7 the whole sample was distributed into four learning styles according to the grade. The highest value for both grades is for converging learners with 724 students (38.84%); 34.70 % for grade five and 42.92% for grade six which is consistent with computed averages for AC-CE and AE-RO shown in Table 13. Divergent and accommodator learning styles in grade five were the lowest percentages with 20.22% and 21.73 % respectively. While, for grade six, accommodator and assimilating learning styles with 18.00% and 15.55% respectively are the lowest percentages.

Table 14: The distribution of the sample according to learning styles

Grade	Learning Styles				Grand Total
	Accommodating	Assimilating	Converging	Diverging	
Grade Five	201(21.73%)	216(23.35%)	321(34.70%)	187(20.22%)	925(49.62%)
Grade Six	169(18.0%)	146(15.55%)	403(42.92%)	221(23.54%)	939(50.38%)
Grand Total	370(19.85%)	362(19.42%)	724(38.84%)	408(21.89%)	1864(100%)

Figure 6: Kolb Learning Styles Distribution of the entire sample

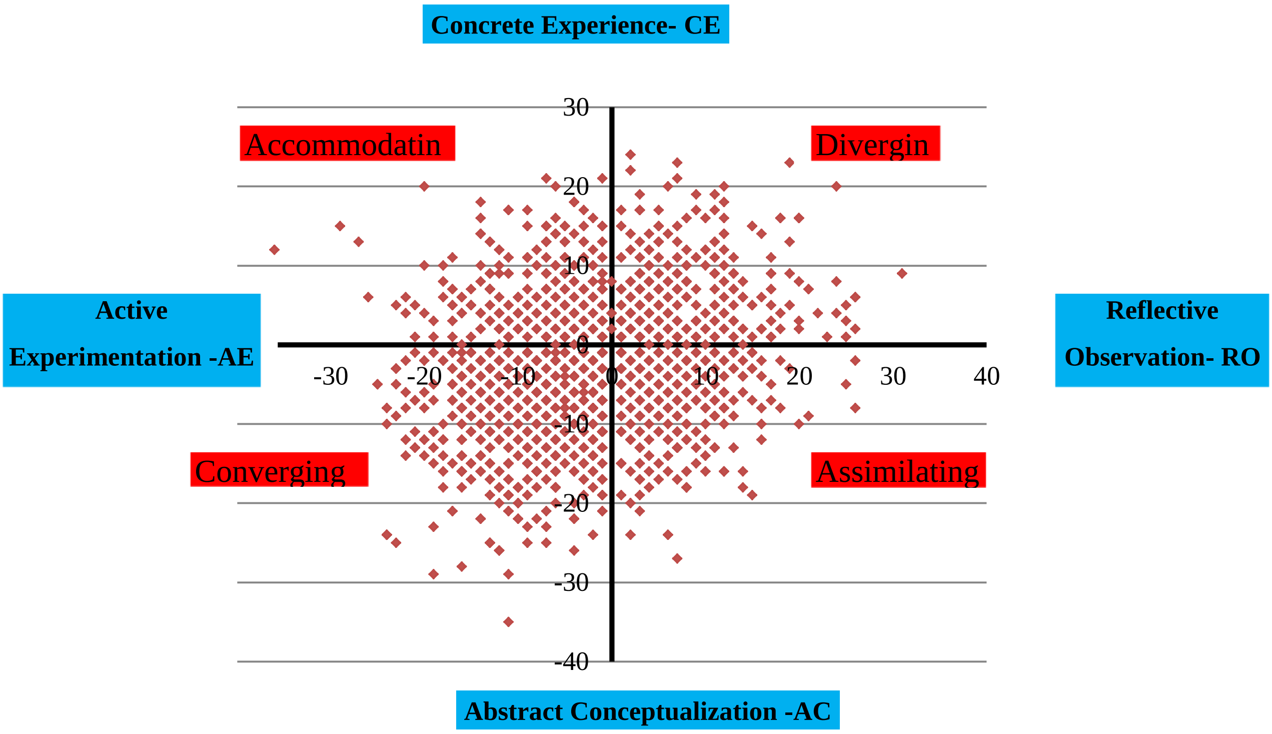
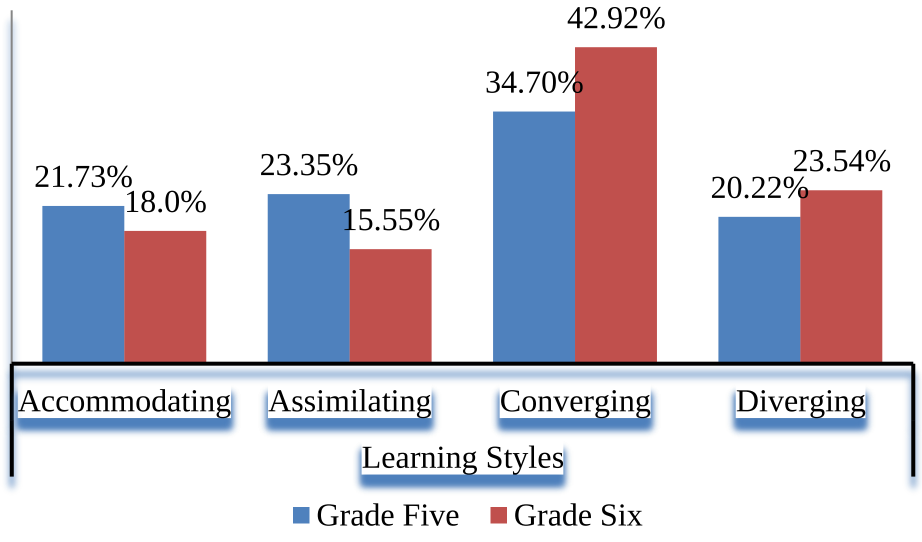


Figure 7: The distribution of the two grades according to their learning styles



Even though, the dominant learning style in both grades is converging with 34.70% and 42.92% respectively, in grade five the next dominant learning style is assimilating with 23.35% followed by accommodating with 21.73%. However, diverging and accommodating in grade six are the next dominant learning styles with 23.54% and 18.00% respectively. The meaning of the obtained results indicated that students' learning styles varied from grade to grade which, required checking students' learning styles at the beginning of each academic year. The difference over grade might be due to a growth curve (Uzuntiryaki 2007; Price 1980; Dunn & Griggs 1995) whereby students' learning styles change as students develop. Therefore, it is necessary to understand individual learning style in order to provide students with suitable teaching approaches to improve their academic achievement (Graf & Kinshuk 2007; Brown et al. 2006; Bajraktarevic & Fullick 2003; Carver et al. 1999; David & Martin 1994) and to help them understand and comprehend different mathematical concepts consequently minimize their misconceptions. For example, in this study's findings, the predominant learning style is converging, and so when it comes to teaching fractions, teachers should employ problem-solving approaches, practical applications of ideas, projects, model buildings, and fieldwork and stay away from social and interpersonal issues. Additionally, the results indicated that students learn differently. Teachers and educators should consider this fact if they want learning to take place.

Research Question 2

What differences, if any, exist in learning styles preferences between fifth and sixth grades' students?

In order to reveal whether substantial differences in learning styles at $(\alpha = 0.05)$ is statistically significant, a Chi-Square Independence (χ^2) test was performed as shown in Table15. The analysis of the Chi-Square Independence test $(\chi^2 = 28.32, df = 3; p = 000)$ shows that the differences between the two grades learning styles are statistically **s**ignificant with $p - value = 0.000 < 0.005$. Therefore, there is a statistical difference between student learning styles preferences and the grade they are enrolled in; or there is enough evidence to say that grade five and six students learn differently.

Table 15: The Chi –Square (χ^2) Independence test for differences between the two grades according to their learning styles

Grade	Learning Styles				Total
	Accommodation	Assimilation	Converging	Diverging	
Grade 5	201(21.73%)	216(23.35%)	321(34.70%)	187(20.22%)	925(49.62%)
Grade6	169(18.00%)	146(15.55%)	403(42.92%)	221(23.54%)	939(50.38%)
Total	370(19.85%)	362(19.42%)	724(38.84%)	408(21.89%)	1864(100%)

Research Question 3

What types of misconceptions about dividing fractions do students of grade five and six hold?

The third research question aims at finding out types of misconceptions the two grades five and six hold about dividing fractions; to answer it, a frequency table with percentage for each error was computed as shown in Table 16. According to Luneta and Makonye (2010), Riccomini (2005) and Cox (1975), if the error is repeated in 25% or more of all students' errors, it will be considered a misconception. As shown in table 4, three errors were selected as misconceptions; the first one is multiplication without flipping with 28.7 % of the sample holding this misconception. Lack of fraction concepts is the second misconception with 28.96% of the sample, and finally the misconception of flipping the dividend is present in 31.81% of the sample.

Table 16: The number of students and percentages of each error

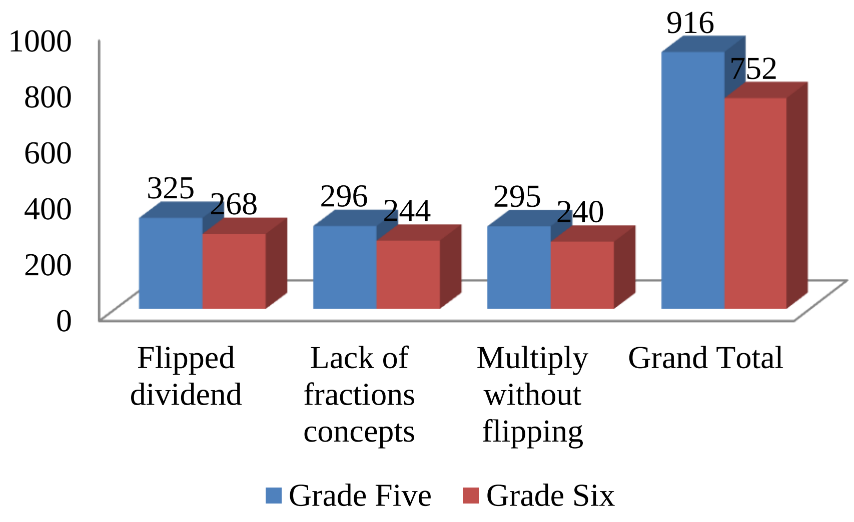
Error Type	Number of Students	Percentage
Flipped dividend	593	31.81%
Lack of fractions concepts errors	540	28.97%
Multiplication without flipping	535	28.70%
Cross-multiplied	75	4.02%
Flip the dividend and the divisor	38	2.04%
Errors in changing forms	30	1.61%
Left blank	28	1.50%
Whole-number errors	25	1.34%
Kept denominator	0	0.00%
Miscellaneous	0	0.00%
Total	1864	100%

As illustrated in both Table 17 and Figure 8, both grades hold the flipped dividend misconception at a percentage of 31.81% (35.14% of grade five and 28.54% of grade six students). In this misconception, instead of flipping the divisor, the students flipped the dividend and then multiplied. This type of misconception occurred when students confuse using the taught algorithm (Tirosh 2000; Ashlock 1994; Barash & Klein 1996) or might be because the students are learning mathematics in Arabic; they consider the dividend is the divisor. The second misconception that the two grades are holding is the lack of fraction concepts with 28.96 % (32% of grade five and 26.0% of grade six students). In this misconception, the students show that they do not comprehend or have the fraction concepts, comparing fractions, equivalent fractions, and representation of a fraction on the number line, and lowest terms, and improper and mixed fractions. Finally, 28.7 % of students hold the multiply without flipping misconception (31.9% of grade five and 25.6% of grade six students). In this misconception, the students confuse division of fractions with multiplication of fractions.

Table 17: The distribution of misconceptions according to the grade

Misconception	Grade		Grand Total	Percentage
	Five	Six		
Flipped dividend	325	268	593	35.55%
Lack of fractions concepts	296	244	540	32.38%
Multiply without flipping	295	240	535	32.07%
Grand Total	916	752	1668	100%

Figure 8: The distribution of misconceptions according to the grade



Research Question 4

What differences, if any, exist in misconceptions about dividing fractions between fifth and sixth grades' students?

In order to determine if the difference in holding misconceptions between the two grades is statistically significant at $\alpha = 0.05$, the analysis of the Chi-Square (χ^2) independence test $(\chi^2 = 10.016; df = 2; p = 0.992)$ as shown in Table 18 reveals that the differences between the two grades misconceptions are not statistically valid with $p - value = 0.992 > 0.05$. There is no evidence to say that the two grades are holding different misconceptions. This result indicated that the two grades have the same misconceptions. Even though the two grades hold the same misconceptions, grade six students improvement compared to grade five students in each misconception. For example, in the lake of fractions concepts, 54.81 % of grade five students hold this misconception compared to 45.19% of grade six students who hold the same misconception.

Table 18: The Chi- Square (χ^2) Independence test for differences between the two grades according to their Misconceptions

Misconception	Grade		All
	Five	Six	
Flipped dividend	325(54.81%)	268(45.19%)	593(35.55%)
Lack of fractions concepts	296(54.81%)	244(45.19%)	540(32.38%)
Multiply without flipping	295(55.14%)	240(44.86%)	535(32.07%)
All	916(54.92%)	752(45.08%)	1668(100%)

The result of the Chi-Square independence test shown in Table 17 confirmed the results concluded by Russell, O'Dwyer, and Miranda (2009) in that there was no statistical significance in holding a specific misconception due to grade or group membership. Also, the present finding seems to be consistent with Yousef and Malone (2003) which found that students of the two grades are making the same misconceptions in solving fraction problems. However, the result is inconsistent with many other studies (Leu & Lin 2010; Jones 2006; Steinle 2004) that found as students move from a lower grade to a higher one, they hold fewer misconceptions in mathematics.

Additionally in order to check if we will obtain the same results and if there is an improvement from the lower grade to the higher one, the differences between the two grades in each misconception were separately examined. The proportion test was performed as shown in Tables: 19, 20, and 21 for each misconception for the two grades separately.

1) Is there a statistical difference between the two grades in held the lack of fraction concepts misconception?

The analysis of the proportion test mentioned in Table18 reveals that since the calculated value of $Z = 2.9 > Z_{\frac{\alpha}{2}} = 1.96$, the statistical difference between the two grades is valid with $(p-value = 0.0037 < 0.05)$. This result indicated that there is association between the lack of fraction concepts and student's grade. This link means that grade five students tend to hold this misconception more than grade six students, since 32 % of grade five has this misconception compared to 26 % for grade six students. This result shows that an improvement occurs when students move from lower grade to the higher one.

Table 19: The distribution of students holding the lack of fraction concepts misconception according to the grade

Lack of fractions concepts	Grade		Grand Total
	Five	Six	
Did not hold misconception	629(68.0%)	695(74.0%)	1324((71.0%)
Hold misconception	296(32.0%)	244(26.0%)	540(29.0%)
Grand Total	925(49.62%)	939(50.38%)	1864
Proportion	$P_1 = 0.32$	$P_2 = 0.26$	

$$\hat{P} = 0.29,\ \hat{q} = 0.71$$

$$Z = \frac{P_1 - P_2}{\sqrt{(\hat{p}.\hat{q})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$Z = 2.9$$

2) Is there a statistical difference between the two grades in held the multiply without flipping misconception?

The analysis of the proportion test mentioned in Table 19 reveals that since the calculated value of $Z = 2.9 > Z_{\frac{\alpha}{2}} = 1.96$, the statistical difference between the two grades is valid with $\left(p-value = 0.0037 < 0.05\right)$. This result indicated that grade five students tend to hold this misconception more than grade six students do, which indicates that an improvement occurs when the students move from lower grade to higher one.

Table 20: The distribution of students holding the multiply without flipping misconception according to the grade

Multiply without flipping	Grade		Grand Total
	Five	Six	
Did not hold misconception	630(68.0%)	699(74.0%)	1329(71.0%)
Hold misconception	295(32.0%)	240(26.0%)	535(29.0)%)
Grand Total	925(49.62%)	939(50.38%)	1864
Proportion	$P_1 = 0.32$	$P_2 = 0.26$	

$$\hat{p} = 0.29, \hat{q} = 0.71$$

$$Z = \frac{P_1 - P_2}{\sqrt{(\hat{p}.\hat{q})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$Z = 2.9$$

3) Is there a statistical difference between the two grades in held the Flip dividend misconception?

The analysis of the proportion test presented in Table 20 reveals that in the calculated value of $Z = 2.73 > Z_{\frac{\alpha}{2}} = 1.96$, the statistical difference between the two grades is valid with $(p-value = 0.0063 < 0.05)$. This result indicated that grade five students hold this misconception more than grade six students do. This indicates that an improvement occurs when the students move from lower grade to a higher one.

Table 21: The distribution of students holding the flip dividend misconception according to the grade

Flipped dividend	Grade		Grand Total
	Five	Six	
Did not hold misconception	600(65.0%)	671(74.0%)	1271(68.0%)
Hold Misconception	325(35.0%)	268(29.0%)	593(32.0%)
Grand Total	925(49.62%)	939(50.38%)	1864
Proportion	$P_1 = 0.35$	$P_2 = 0.29$	

$$\hat{p} = 0.32,\ \hat{q} = 0.68$$

$$Z = \frac{P_1 - P_2}{\sqrt{(\hat{p}.\hat{q})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$Z = 2.73$$

This result is consistent with Stine (2004) and Jones (2006) who concluded that as students move from a lower grade to a higher one, they tend to hold fewer misconceptions in mathematics.

However, the analysis of the Chi-Square (χ^2) Independence test was different from what we obtained when we examined the associations between each misconception separately. The possible reason for this result might be due to the fact that some students in the sample hold more than one misconception at the same time.

Research Question 5

What is the relationship between students' learning styles based on Kolb's (1985) model and held misconceptions about dividing fractions?

In order to examine if there is a relationship between held misconceptions about dividing fractions and students' learning style preferences at $\alpha = 0.05$, the analysis of the Chi- Square (χ^2) independence test was performed as shown in Table 22. The results of $(\chi^2 = 244.23; df = 6; p = 0.000)$ reveals that the differences between the two grades' misconceptions and their learning style preferences are statistically significant with $p - value = 0.000 < 0.05$. Since the Chi-Square Independence value is too large $(\chi^2 = 244.23)$ and small $\left(p - value = 0.000\right)$, the difference between the expected and count values is too large to be by chance, and there must be a relationship between the two variables.

Table 22: The Chi Square (χ^2) Independence test for differences between the two grades misconceptions in dividing fractions and their learning style preferences

Misconceptions	Learning Styles				Total
	Accommodating	Assimilating	Converging	Diverging	
Flipped dividend	64(10.79%)	140(23.61%)	181(30.52%)	208(35.08%)	593(35.55%)
Lack of fractions concepts	75(13.89%)	97(17.96%)	230(42.59%)	138(25.56%)	540(32.38%)
Multiply without flipping	215(40.19%)	105(19.63%)	173(32.34%)	42(7.85%)	535(32.07%)
Total	354(21.22%)	342(20.50%)	584(35.01%)	388(23.26%)	1668(100%)

The answer of this question reveals that there is a relationship between how student learn and make misconceptions about dividing fractions. The result of this study is consistent with other studies (Poon & Leung 2009; Wilson 2001) that found there is a strong correlation between students' spatial abilities and held misconceptions in solving algebraic equations that include fractions such as $\frac{a}{b+c} = \frac{a}{b} + \frac{a}{c}$. Further, (Poon & Leung 2009; Wilson 2001) confirmed that if mathematics teachers did not give enough attention to how students learn, they would spend a lot of time and effort in delivering and processing new mathematics subjects that would not rectify the main causes behind the problem. Also, the result is consistent with Knisley (2002) which concluded that visual students tend to hold misconception in reducing the expression $\sqrt{x^4 + 4x^2}$ by gave the answer as $x^2 + 2x$. Furthermore, many researchers (e.g., Wilson 2001; Peker & Mirasyedioglu 2008; Knisley 2002) concluded that students' mathematical abilities are due to the fact that students have different learning style preferences. Also, they indicated that involving all learners (with different learning styles) in the class will challenge the students intellectually and provide them with meaningful tasks. Yousef and Malone (2003) also reported that each student committed errors and misconceptions when dealing with fractions and these errors and misconceptions differ from student to student, even though they get the same instruction in class and are taught by the same instructor. This indicates that each student has his/her own learning style and teachers must be aware of these differences in learning and dealing with misconceptions according to the students' needs and learning style to overcome them. Besides, Rakes (2010) confirmed that students' misconceptions and enjoyment of mathematics learning are two factors that are associated with minimizing or reducing their misconceptions and errors.

Research Question 6

What difference, if any, exist between fifth and sixth grades' students learning styles and the type of fraction misconceptions?

As shown in Table 23, the divergent students tend to hold flipped dividend with 35.08%. The reason for that, in this learning style the student tend to be imaginative, emotional, feeling oriented depends on concrete activities and not able to work or digest the abstract concepts. Also, the learner in this category is described as visual learner who likes to see, demonstration, diagrams, and slides or photos (Villaverde et al. (2006). Also Yannibelli et al. (2006) assured that visual learners tend to forget when something is simply said and they prefer verbal or written explanations. Whereas, 42.59 % of the sample are convergent learners tend hold the lack of fractions concepts misconceptions. In this learning style category, the learner prefers to use practical ideas and using and applying concepts in different situations and learn by doing. Also, the learner in this category is described as kinesthetic or tactile learner. Also, this type of learner prefers to carrying out a physical activities and is not able to do mental math or memorizing concepts. Therefore, using a lecturing, watching or a demonstration approach with this type of learners, which focused on abstract ideas without involving students in practical projects that enable them to apply what they have learned in real life situations, would increase the possibilities of making this type of misconceptions when they solve fractions problems. With respect to the third misconception, multiply without flipping, the accommodating learner tends to hold it with 40.19 % of the sample. The accommodating learner depends on others to perform mathematical problems and to get information and prefers to conduct experiments. Therefore, this type of learner, in order to help him in avoiding making such misconceptions, has to be involved in team teaching and introduce the division of fractions in other science subjects such as using fractions in doing chemistry experiments.

Table 23: The distribution of students' misconceptions according to their learning styles preferences

Misconceptions	Learning Styles				Total
	Accommodating	Assimilating	Converging	Diverging	
Flipped dividend	64(10.79%)	140(23.61%)	181(30.52%)	208(35.08%)	593(35.55%)
Lack of fractions concepts	75(13.89%)	97(17.96%)	230(42.59%)	138(25.56%)	540(32.38%)
Multiply without flipping	215(40.19%)	105(19.63%)	173(32.34%)	42(7.85%)	535(32.07%)
Total	354(21.22%)	342(20.50%)	584(35.01%)	388(23.26%)	1668(100%)

Summary of Results

This chapter reported and interpreted results in order to answer the research questions. Additionally, the results were justified in light of other studies conducted to examine the same phenomena. Data was analyzed by using different statistical techniques such as descriptive statistics, proportion and the Chi-Square independence tests.

This study set out to investigate the relationship between held misconceptions about dividing fractions and students' learning styles. The outcomes of this study reveal that the predominate learning style for both grades is converging learners with 724 students (38.84%), 45.51 % for grade five and 42.92% for grade six. Even though the dominant learning style in both grades is converging, in grade five the next dominant learning style is assimilating with 23.35% followed by accommodating with 21.73%. Whereas, diverging and accommodating in grade six are the next dominant learning styles with 23.54% and 18% respectively. The meaning of the obtained results indicate that students' learning styles varied from grade to grade as was confirmed by the Chi-Square independence test, which required checking students' learning styles at the beginning of each academic year.

With respect to the students misconceptions, three misconceptions were identified; the first one is flipping the dividend with 31.81%, then lack of fraction concepts is the second misconception with 28.97% of the sample, and finally multiply without flipping with 28.7 % of the sample holding this misconception. Additionally, the results of this study reveal that generally, both the two grades five and six students had misconceptions on fractions. Moreover, the outcomes of this study show that both grades experienced difficulties in mastering basic fraction concepts. Further, the study reveals that both grades have misconceptions and there is slight educational improvement in fractional comprehension from grade to grade, even though the same misconceptions were committed by the two grades. Also, one of the more significant findings to emerge from this study is that there is a relationship between held misconceptions and learning styles in dividing fractions. The results showed that a specific misconception is related with a specific type of learning styles. The divergent learner (visual) tends to hold flipped dividend misconception with 35.08%, and the convergent learner tends to hold lack of fraction concepts misconceptions with 42.59%. Finally, the accommodating learner tends to hold multiply without flipping with 40.19%.

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

The chapter begins with a summary of the obtained results according to the research questions being examined then describes the implications of this study and suggestions for future research. Similar to all educational studies, this study has some limitations that are discussed.

Findings and Conclusions

Since the sample of this study was large $(N = 1864)$, randomly selected, and all data was collected during the regular mathematics periods, all schools and students were in the same environment, there is no limitation to generalizing the study's results to the whole population.

The outcomes of this study reveal that the whole sample was distributed into four learning styles according to the grade. The highest value for both grades is for convergent learners with 724 students (38.84%); 34.7 % for grade five and 42.92% for grade six, followed by assimilating with 23.35% and accommodating with 21.73%. Whereas, diverging and accommodating in grade six are the next dominant learning styles with 23.54% and 18.00% respectively. The meaning of the obtained results indicates that students' learning styles varied from grade to grade. This implies that students' learning styles need to be checked at the beginning of each academic year. The difference over grades might be due to a growth curve (Uzuntiryaki 2007; Dunn & Griggs 1995; Price 1980) meaning the students' learning styles change as students develop. Additionally, the results confirm that students are learning differently and there is a relationship between students' learning styles and the grade they are enrolled in. This result is consistent with the study of Jones et al. (2003) who indicated that only 19% of the participants stayed in the same learning style within different disciplines, and their learning styles varied from one subject to another. Additionally, Kaya et al. (2009), in their study that investigated primary school students' learning styles on a sample of 687 students distributed into three grades- six, seven, and eight- revealed that there are meaningful differences in students' learning styles according to the grade and that there is a relationship between students' learning styles and class grade at $\alpha = 0.05$. Also, this result appears to be consistent with other results (for example, Demirbas & Demirkan 2003, 2007; De Boer & Steyn

1999; Nulty & Barret 1996; Dunn & Griggs, 1995; Wallace 1995; Price 1980) which mentioned that students' learning styles are different and there is a dominant one. Additionally, the results of this study are consistent with the study of Tucker (2008) that showed the dominant learning style among the first and second year architecture students is converging in 34% of the entire sample and assured that the learning styles varied from year to year of study. Moreover, Ergin and Sari (2008) concluded in their study that the dominant learning styles for high school students is converging with 67% followed by assimilating with 28.75%. Moreover, in Deryakulu and his associates study (2010), it was concluded that 51 participants out of 148 (34.5%) were convergent learners followed by 33.1% that were assimilators. The outcome of this study confirmed the Orhun (2007) study, which revealed that 64% of the participants $(N=73)$ were convergent learners, 42.5% were assimilators, and none were accommodator learners.

However, the result of this study is inconsistent with that of Callan (1996), which mentioned that students in the same grade have different learning styles and there is no dominant one. Also, in a study conducted by Draper (2004) on a sample of 101 grade six students, it was concluded that 35% of the sample were accommodating, 25% diverging, 24% assimilating and only 17% were converging. Also, the outcomes of this study are inconsistent with Kanninen's (2008) study which concluded that 36% of students were assimilating and followed by 31% diverging and inconsistent with the study of Jones and his colleagues (2003) which reported that out of 105 participants, 59% were assimilator learning style. Whereas, Ozkan's (2003) study reported 50.2% of the participants $(N=980)$ were assimilators followed by 26.2% being convergent learners. In contrast with Ozcan's study, Kaya, Ozabach and Tezel (2009) reported that all grades in their study were diverging learners, with 39.3%, 34.6%, and 31.6% for the grades six, seven, and eight respectively. Also, the results of this study are inconsistent with the Pecker and Aydin (2003) study that concluded 54.5% of the sample $(N=284)$ was assimilator followed by 29.4% convergent. Whereas, Can (2011) reported in his study that conducted on 409 students that no significant relationships were found for age, gender, and learning style.

With respect to type of misconceptions in dividing fractions that the two grades hold, the results of this study reveal that most of grade five and six students in Abu Dhabi public schools have difficulties performing and comprehending fractions.

Concerning the type of misconceptions the two grades students hold, the study reveals that 31.81% of the sample hold flipping the dividend misconception, 28.97% of them hold lack of fraction concepts misconception, and 28.7% of the two grades hold multiplying without flipping misconception.

Despite the fact that the two grades make the same misconceptions in dividing fractions, grade six students show an improvement with respect to that 26.0 % of them hold lack of fractions concepts and multiply without flipping misconceptions compare to 32.0% in grade five. With respect to the flipped dividend misconception, 29.0% of grade six students hold this misconception compare to 35% in grade five students.

This result appears to be consistent with other studies that are related to lack of fractions concept misconception (Idris & Narayanan 2011; Yousef & Malone 2003; Wu 2001; Tirosh 2000; Ma 1999; Spungin 1996; Brown et al. 1990; Brown et al. 1990; Post et al. 1988;Carpenter et al. 1981). In Post et al. (1988), 20% to 30% of the participants showed the same error patterns in understanding fractions concepts. Also, Cramer and Lesh (1997) found that 20% of students did not show a level of conceptual understanding of fractions. Brown and Quinn (2006) conducted a study aimed at analyzing students' errors and misconceptions about fractions. The study revealed that most of the students demonstrated errors in understanding basic fraction concepts. Moreover, the study concluded that 25% of the sample $\left(N=143\right)$ did not rename the mixed number correctly, 27% of them did not correctly simplify the fraction $\frac{24}{36}$ to its lowest terms, 66% of the sample did not solve fractions' word problems involving basic fraction concepts, and 58% of the students did not write the fraction $5\frac{2}{7}$ as a sum. These results indicated that the students showed a lack of fraction concepts, and how to use them in different situations. Moreover, the same study aimed to check if the students have comprehended fractions' comparison. For example, 67% of the students gave an incorrect answer in comparing $\frac{1}{2}$ and $\frac{1}{3}$. Additionally, in the example to put the fractions: $\frac{4}{7},\frac{5}{9},\frac{3}{5}$ in order from least to greatest, 43% of the sample did not order the fractions correctly. Whereas, in Newstead and Murray (1998), 38% of grade six and 16% of grade four students failed to put the following fractions $\frac{2}{5},\frac{2}{3},\frac{2}{9}$ in order from smallest to largest, and 30% of grade six and 18% of grade four students failed to select the larger fraction of $\frac{3}{5}$ and $\frac{3}{4}$. In comparing the two fractions, the students considered only the size of the denominators of the two fractions (Baroody & Hume 1991). Additionally, 20% of grade four and 35% of grade six students failed to give a geometrical representation of the fraction $\frac{3}{4}$. Also, the result of the study is consistent with the results of Idris and Narayanan (2011) which aimed to find out students' systematic errors in addition and subtraction of fractions. The results indicated that 50.6% of the systematic errors were related to fraction concepts in terms of simplifying the final answer to the lowest terms. 26.2% of students faced difficulties in understanding fraction concepts. In addition, 26.4% of them encounter difficulties in dealing with improper fractions. According to the study of Yousef and Malone (2003), which aimed to find mathematical errors in fractions, it was reported that basic concepts errors are higher than all other types of errors exhibited by grade six students. This type of error affects students' ability to perform operations on fractions and their abilities to comprehend and understand other mathematics fields (Byrant 1995; Swedosh 1996). Also, according to Swedosh (1996) the lack of fraction concepts has a direct effect on the success of students in other mathematical topics in the future such as algebra. Swedosh further indicated that understanding and comprehending basic fraction concepts determine the preparedness of high school students to acquire advanced mathematical subjects.

In Brown and Quinn (2006), 42% of students failed to answer the question $\frac{1}{2}\div\frac{1}{8}\cdot$The students thought that the quotient should be smaller than the divisor (Baroody & Hume 1991). Also, 26% of the students obtained the answer by multiplying the two fractions without flipping the divisor. In another example, $1\div\frac{1}{6}$, 53% of the students failed to solve it by finding the reciprocal of the dividend, and gave the incorrect answer of $\frac{1}{6}$, which means that the students multiply without flipping the divisor (Lamon 1999). Also, Clement indicated in his study that students in solving the problem $\frac{1}{2} \div \frac{3}{2}$ gave the incorrect answer $\frac{3}{4}$ by multiplying the two fractions without finding the reciprocal of the divisor. Whereas, in Newstead and Murray (1998) 21% of grade six students failed to answer the question $2 \div \frac{1}{2}$; they gave one as an answer by multiplying without flipping the dividend, and they showed their inability to clarify the question as 'how many $\frac{1}{2}$'s are there in 2.' Furthermore, 32% of grade four and 50% of grade six students failed to solve the question $4 \div 8$. The students in solving the question misapplied the commutative property, which can be implemented in the adding of whole numbers. The misapplication of commutative property appeared in Tirosh (2000) and Hart (1981) studies, where 49.2% and 32.6% of students in both studies respectively exhibited this type of misconception. Whereas, in Bulgar (2009), the same misconception appears in the students' answers, in solving the problem $2 \div 6$, the answer of the grade four students was three. The student reversed the dividend and the divisor. In Jones (2006), seven students out of 85 flipped the dividend instead of the divisor in solving the question $\frac{2}{9} \div \frac{3}{8}$. In the same study, the number of mistakes regarding flipping the dividend decreased when the divisor was not a whole number. Mundia et al. (2010) aimed to find high school students' difficulties in learning mathematics and revealed that 93% of the participants failed to answer a division problem by inverting the wrong fraction before performing the problem.

From previous error analysis, many conclusions about students' knowledge and understanding of fractions can be clarified. The students seemed to have serious problems in comprehending and understanding the meaning of dividing fractions, and how to use different algorithms to get the correct answer. Also, students hold misconceptions that related to their prior whole number knowledge and knowledge of fractions. For example, many of the students kept the denominator unchanged when they were supposed to multiply by the reciprocal of the divisor. Finally, many students showed a serious problem in comprehending basic fraction concepts such as improper and proper fractions, simplifying the answer to the lowest term, comparing fractions, changing mixed numbers into improper fractions, equivalent fractions and fractions' representations.

Therefore, when it comes to teaching fraction concepts, middle school teachers have to introduce these concepts in situations that relate fractions to real-life contexts (NCTM 2000) and to delay teaching operations on fractions until they are sure that their students have a solid understanding of basic fraction concepts. Also, mathematics teachers have to link fraction concepts and procedures, which will improve their achievement and allow students to learn new ideas (NRC 2001). Moreover, Van de Walle (2004) recommended that in order to minimize these misconceptions in fractions, teachers are supposed to provide their students with opportunities to be involved in activities that require different and multiple external representations to occur in a single problem, and help students to develop connections between these representations and their meaning of fractions' concepts. Furthermore, employing or using different representations of fractions requires the students to have flexible learning approaches and thinking (Bulgar 2009). Also, an appropriate classroom environment and teaching approaches that match students' learning styles help teachers to enhance students' opportunities in comprehending and understanding fractions (Maher, Davis & Alston 1991). Besides, Lamon (2001) encourages students to develop their own fraction representations to make sure that the students are using their own learning approaches and as an indicator of understanding. The result of Sharp and Adam's study (2002) confirmed the conclusion of Lamon (2001) with regards to letting students use their own learning and to encourage them to create new algorithms in solving fraction problems. For example, Sharp and Adams found that using the common denominator approach in solving fractions' division problem might help students in overcoming their deficiencies in division and build more naturally on student conceptual knowledge of whole numbers. From this, the ability of students in moving among and between representations of division of fractions is considered an indicator of a deep understanding of fractions' division (Bulgar 2009).

Even though many researchers (e.g., Tzur 2004; Bulgar 2003; Mack 1990, 2000; Olive 1999; Warrington 1997; Saenz-Ludlow 1994) support the idea of letting students use their own learning approaches and inventing new algorithms to solve fraction problems, Morris (1995) reported in his study that students could make errors if they invent new procedures.

The current study examines the relationship between grades five and six, students' misconceptions, and their learning styles. Two data collection instruments were used; a mathematics diagnostic test consisting of twenty items in two sections, and the Kolb's Learning Style Inventory. The sample consists of 978 female students (52.5%) and 886 male students (47.5%) distributed according to the two grades as, 925 students in grade five (49.62 %) and 939 students in grade six (50.38 %). Different statistical techniques were used to analyze the collected data such as descriptive statistics, proportion, and the Chi-Square independence $\left(\chi^2\right)$ tests.

The outcome of this study concludes that students in the two grades five and six hold misconceptions about dividing fractions, and the differences between the two grades is statistically significant at $\alpha = 0.05$.

These misconceptions are different from student to student even though they get the same instruction in the same educational environment. This difference between students might due to the fact that each student has his/her learning style preference. The inference that we can conclude is that mathematics teachers have to be aware of the students' differences in making misconceptions, and to be able to deal with these misconceptions by identifying students' learning styles at the beginning of each semester or academic year, and using teaching approaches or strategies that match their students' learning style preferences. The matching between students' learning styles and teaching approaches employed by teachers will enhance the learning processes (Felder & Brent 2005). Moreover, teachers have to develop instruction strategies in order to address students' misconceptions and to enhance their conceptual understanding. According to Silver (1986), teachers have to "examine the possibility that our instructional procedures may reinforce the error rather than eradicate it" (p.190). Along with that, other researchers (e.g., Souleles 2013; Crabtree 2008; Tzur 2004; Bulgar, 2003: Mack 1990, 2000) asserted that instructional procedures employed by teachers have to assist students in creating their own solutions and that can achieved if teachers match their approaches with students' learning styles.

The findings also reinforce the importance of students' learning styles in making misconceptions in mathematics in general and on fractions in particular. The importance of studying students' misconceptions and learning styles contributes to the improvement of teaching strategies in order to help students in overcoming these misconceptions and improving their achievement in mathematics (Dole 2003). Coffield (2004) and Suskie (2002) also assured that knowing students' learning styles would increase students' awareness, reinforce strength areas and rectify weaknesses. Moreover, studying of students' misconception will provide teachers with important information as to why students did not answer specific questions correctly (Ketterlin-Geller & Yovanoff 2009).

More attention from all stakeholders in the educational system in Abu Dhabi has to be given to professional development of mathematics teachers to improve the teaching approaches they use in classes, encourage them to apply different teaching methods, and make the student the center of the learning-teaching processes. Additionally, when teaching fractions, teachers should avoid traditional teaching (Pappalardo 2013) and should employ practical and technical activities and projects in order to maintain students' understanding and comprehending of fraction concepts and operations. Since the traditional fraction instruction according to many researchers (e.g., Rice 2003; Stigler & Hiebert 1999) has an effect on students' poor performance in fractions at all students' academic level, it consequently has a direct effect on held misconceptions of fractions (Silver 1986). Besides, mathematics teachers have to use concrete objects and activities and focus on a conceptual approach which means that teachers are supposed to concentrate on teaching fractions on acquiring fraction concepts which will allow students to tackle greater mathematical difficulty and complexity, then they can move on to the fraction operations.

Additionally, according to Shamsiah and Clements (2002) in teaching fraction concepts, teachers should use different fraction representations, and let students invent new algorithms and approaches in performing operations on fractions and linking fraction concepts and procedures in order to help them learn and use new ideas (NRC 2001). The connection between students' mathematical concepts and the procedures in solving a particular problem is important to reinforce students' struggle in understanding and learning fractions (Rakes 2010; Kieran 2007; Skemp 2006). Finally, there should be workshops for teachers to assist them in identifying students' misconceptions and learning styles in mathematics in general and about fractions in particular. Moreover, helping teachers to develop more refined instruments that have the ability to identify and categorize students' misconceptions is necessary. It is more vital for mathematics teachers and educators to be empowered by approaches or strategies in order to help students overcome or reduce their misconceptions (Kembitzky 2009). This study can be used as evidence for educational stakeholders in Abu Dhabi to give more attention to teacher training and professional development. Since the prevalence of misconceptions about fractions may influence the foundations of how students learn other mathematical subjects or topics, professional development is needed in order to improve their abilities and instructional approaches or practices in dealing with the misconceptions phenomena and difficulties in learning mathematics in Abu Dhabi.

Unlike other studies (e.g. Suffolk & Clements 2003; Suffolk 2001) that have been conducted in the field of fractions, this study is the first study conducted in UAE/ Abu Dhabi that reveals the importance of students' learning styles and misconceptions. This provides valuable information on Abu Dhabi students' difficulties in fractions and some ideas regarding how to overcome these difficulties in the future.

Since the results of this study reveal that most of students of both grades are convergent learners (38.84%), their learning depends on practical things and their applications. Mathematics teachers in Abu Dhabi should stay away from a teacher-centered approach that contradicts or conflicts with their students' learning approaches and they should give more time to their students to employ hands-on activities and use of concrete equipment to maintain their understanding and help them implement fractions in real-life contexts (Sharp & Adams 2002). Moreover, teachers' awareness about how their students learn and think influences the nature of the relationship teaching methods and learning styles and will help teachers to direct teachers' instruction level. Furthermore, teachers have to give more attention to how their students learn mathematics and give them more time in classes to make sense of fractions on their own (Mack 1998). Along with that, Oberdorf and Taylor-Cox (1999) asserted that teaching methods used in classes exacerbate misconceptions if they do not match with how students learn.

The current study reveals several fraction misconceptions in grades five and six in Abu Dhabi public schools. Furthermore, the study categorizes the two grade students learning style preferences and the relationship of learning styles and held misconceptions on fractions. Also, this study reveals that Abu Dhabi grade five and six students have deficiencies in learning fractions. Therefore, the results of this study can be used to rectify these deficiencies at this stage in order to prevent the appearance of the same misconceptions or their presence in high schools (Watson & Shaughness 2004). ADEC has to make efforts to assist teachers to develop their teaching approaches and encourage them to make sure that before moving ahead in fraction operations, their students have mastered basic fraction concepts.

The learning style is considered one of many important factors (e.g., achievement, motivation, and attitudes) that affect learning and teaching mathematics for all educational levels. The differences in students' learning style preferences are vital and have a direct impact or effect on students' learning mathematics and held misconceptions as revealed by the study's outcomes. Students from both grades five and six showed different learning styles. However, the dominant learning style for both grades was convergent learners. Convergent learners prefer to get knowledge or learn through practical uses of mathematical ideas, projects, and experimentation so teachers need to use hands-on activities and projects. Many studies (e.g., Demirbas & Demirkan 2007, 2003; De Boer & Steyn 1999; Nulty & Barret 1996; Shelnutt et al. 1996; Dunn & Griggs, 1995;Wallace 1995; Price 1980) were confirmed in this study's results. Other researchers (Kaya, Ozabach & Tezel 2009; Kanninen 2008; Johns et al. 2003; Ozkan 2003; Draper 2000;Callan 1996) were inconsistent with the outcomes of this study.

The findings of this study consistent with Collinson (2000) that there are manifest statistically significant differences in how students prefer to learn mathematics in classrooms. Moreover, Raschick, and Maypole (1998) and Kolb (1985) both agreed that learning mathematics attracts convergent students, since convergent students tend to use practical ideas and projects in performing mathematical subjects. However, the results show that there is a valid statistical relationship between students' learning style preferences and held misconceptions in dividing fractions. One of the reasons behind that may be due to the fact that teachers used teaching approaches (such as lecturing) in their classes that do not match students' learning preferences. In connection with this, Pewewardy (2002) and Park (2000) indicated that teachers' knowledge of their students' learning styles preferences may help them design additional materials and employ suitable teaching approaches for particular learning styles of students. Kramer-Koehler, Tooney, and Beke (1995) asserted that modifying instructional approaches in order to provide students with a variety of learning environments that suit their learning styles may help improve students' learning and offer them chances to understand what is good for their own educational needs. The match between students' learning styles and instruction approaches will improve mathematics learning of students (She 2005; Dayer & Osborne 1996) and consequently minimize students' misconceptions and contributes to the successes or failures in academic achievement(Pashler et al. 2008; Chan et al. 2007; Doolan & Honigsfeld 2000; Kolb 1984).

In summary, the current study reveals that there are many issues that mathematics teachers have to consider in teaching mathematics in general and fractions in particular. For instance, teachers have to make sure their students have mastered the basic fraction concepts before instructing the fractions operations. Also, using different fractions' representations would help to enhance the students' understanding of the reasons behind applying different algorithms and procedures in solving fractions' operations such as division. Additionally, teachers should clarify for their students that some whole number rules cannot be generalized and used in fractions. For instance, the commutative property in adding whole numbers should not be implemented or over-generalized in dividing fractions.

Implications of Findings and Recommendations

The outcomes of this study have important implications for improving students' understanding of fractions. Taken together, these results assist in our understanding of the role students' learning styles in held misconceptions about fractions and provide vital suggestions for mathematics teachers to be adopted in their teaching. Teachers should participate in professional development programs in order to improve their abilities in dealing with misconceptions. The professional development program has to include ideas on how to design diagnostic tests that have the ability to reveal students' misconceptions in mathematics in general and about fractions in particular. Besides, it has to include activities in how to find out students' learning styles and design teaching strategies in order to match how students' learn with teaching approaches. From my observations while conducting this study, I have noticed that the dominant teaching approach in schools is generally teacher-centered. Since the teaching style is one of the factors that have an effect on students' performance (Ames & Archer 1988), teachers have to make the students the center of the learning-teaching process and encourage them to build the new mathematical knowledge on their own prior one. Furthermore, teachers have to use fraction representations other than area representation while teaching fraction concepts, which will help them in comprehending and performing fractions.

In accordance with my observations mentioned above, mathematics teachers have to make sure that their students understand the algorithm and fraction concepts before proceeding in fraction operations. Additionally, in order to help teachers to realize the sense of mathematics, they have to learn how fraction concepts are related. Teachers' understanding of the relationship between concepts and among external representations (Glenda &Margaret 2009) will help students to form structures (how things are related) "which are seen as fundamental to meaningful learning" (Resnick & Ford 1981, p. 125). In accordance with that, many researchers (Niemi 1996; Wearne& Hiebert 1988) indicated that students learning fractions with understanding contribute to greater improvements in procedures they use and help them to transfer these concepts to new contexts. When mathematics teachers succeed in linking fraction concepts with procedures used by students, this minimizes misconceptions and increases relational understanding (Jones 2006), and helps students to use these procedures appropriately (Wearne & Heibert 1988).

Finally, Guild and Garger (1985) asserted that in formal schools the majority of students are taught using the same teaching strategies. This strategy is attuned to the teacher. In concordance with the fact that students process information differently, each student has his/her learning style and his/her cognitive abilities.

Comprehending and performing fractions is a rooted problem and it has been studied, documented and investigated for a long time. As early as 1958, Hartung assured that a fractions concept is complex and difficult to be grasped all at once. It must be accomplished gradually according to a long process of sequential development. In the 80's and 90's, other researchers investigate the fractions deficiencies and type of errors exhibited by students (e.g., Swedosh 1996; Ashlock 1994; Hasemann 1981). Recently, other studies acknowledged that teaching and learning fractions is one of the most difficult topics in school mathematics (Nunes & Bryant 2008; Stafylidou & Vosniadou 2004; Yoshida & Sawano 2002; Brousseau et al. 2004). Therefore, this comes in order to continue the processes of studying the fractions' phenomena and to find out some other factors that might have a direct effect on improving students' performance.

Limitations of this Study

A number of important limitations need to be considered regarding this study that might have an effect on generalizing the results over the study population. These limitations could be categorized in terms of sampling techniques used and data collection instruments; the weaknesses that related to Kolb's inventory with respect to its limited ability to be used in all situations provides only a limited number of factors that affect individual learning, and it cannot be used for individual selection purposes (Greenway 2004). Another limitation is that Kolb's model has low predictive validity. Further limitations are linked to teachers' experiences, age, gender, qualifications, and statistical analysis adopted.

In terms of the selected sample and segregate them according to gender in Abu Dhabi government schools, there is no solid evidence for or against single gender classes (Herrelko, Jeffries, and Robertson 2009).However, some studies suggested that single gender classes work for some students' communities (Billger 2006). (Herrelko, Jeffries, and Robertson 2009) asserted that male students have the advantage in the visual-spatial abilities, and 72% of teachers participating in their study agreed that single gender classrooms made a positive impact on students' academic achievements in mathematics. However, other researchers (e.g., Dumay & Dupriiez 2008) the impact is exist but usually small. Since the majority of students (95% - 97%) in the sample are Emiratis, and according to the studies mentioned above I do believe there is no impact on this study's results due to the school segregations according to gender.

As I have mentioned earlier, this study has adopted the quantitative approach. However, it will be vital if another study conducted to achieve the same purpose of this study by adopting a mixed –methods study - Sequential explanatory design.

Steckler et al. (1992; p. 4) argues that "combining quantitative and qualitative methods in a single study can help elucidate various aspects of the phenomenon under investigation. Providing a more holistic understanding of it, and resulting in better-informed education policies", and it is useful for answering certain types of question. It enhances the validity of findings by corroboration, convergence, or correspondence of results from using different sources; as well enhance the overall scope of a study (Tashakkori & Teddlie 1998 2003; Johnson & Turner 2003; Greene et al. 1989). Therefore, a second qualitative phase is required by using different data collection instruments. In order to clarify reasons behind students' misconceptions in dividing fractions, semi- constructed interviews will be conducted with a subsample of the students who answered the diagnostic test and got the highest percentages of errors and misconceptions. The interview's questions will be constructed based on the results from the first phase. The purpose of the interviews to confirm the validity of the errors' classification found in the first phase, and to relate each misconception with a specific learning style. The two datasets will be integrated in the interpretation stage.

Therefore, these limitations should be considered when the results are applied in different contexts.

Suggestions for Future Research

The outcomes and limitations of this study propose several venues for other studies. One of such studies is the use of different learning style inventories to examine the relationship between held misconceptions and learning styles. Additionally, more research on this topic should be conducted to find out the relationship between students' learning styles and other mathematical topics misconceptions such as geometry, since geometry requires students to have specific skills such spatial ability.

A further study should investigate the relationship between held misconceptions in mathematics and matching students' learning styles and instruction approaches used by teachers in classes. Given that students' misconceptions are not limited to specific operations on fractions, and there is an overlap between operations on fractions such as multiplication and division. For example, if the student exhibited an error in performing a multiplication problem with a fraction, it will cause an error in performing a fraction's division problem. Therefore, more studies should be conducted by including the four operations with fractions in order to examine the interaction of the four operations on fractions and learning styles.

During earlier visits to schools to conduct and secure the sample of the study, I have noticed that many of them-especially in grade five- are female teachers, and some of them do not hold a mathematics degree. Therefore, other studies should be conducted to find out the impact of teacher's qualification, gender, teaching approaches, and teaching experiences on held misconceptions on fractions. Moreover, a study needs to be conducted to propose, design, and test a remedial program to overcome students' misconceptions. Future research to investigate if using analytic teaching and other factors such as using technology, textbooks, manipulatives (educational games) and teachers' knowledge about students' cognitive development with held misconceptions in mathematics would make a difference in helping students to minimize or overcome their misconceptions.

Finally, another study could be conducted to explore students' beliefs and attitudes towards analyzing their own errors and misconceptions and how that might help in improving their performance in mathematics.

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APPENDICES

APPENDIX-A

KOLB'S LEARNING STYLE INVENTORY (LSI)-ENGLISH VERSION

Kolb's Learning Style Inventory (LSI)

Purpose: This inventory is designed to find out your learning style preference in learning situations.

Instructions:

1. Sentences: This inventory consists of 12 sentences with a choice of four endings. Rank the four endings for each sentence according to how the sentence is fit with how you learn something.
2. Rank: In the space providing with the four endings, try to rank order each sentence ending, starting with " 4 " to the sentence that best describe how you learn, and " 1 " for the sentence ending that looks the least like the way you would learn.

4	**The most relevant/ applicable**
3	**The second most relevant**
2	**The third most relevant**
1	**The least relevant**

1	**When I learn….**	**….**I like to deal with my feelings________	**….**I like to watch and listen ________	**….**I like to think about ideas________	**….**I like to be doing things ________
2	**I learn best when….**	**….**I trust my hunches and feelings ________	**….**I listen carefully and watch ________	**….**I rely on logical thinking ________	**….**I work hard to get things done ________
3	**When I am learning….**	**….**I have strong feelings and reactions ________	**….**I am quiet and reserved ________	**….**I tend to reason things out ________	**….**I am responsible about things ________
4	**I learn by**	**….**feelings ________	**….**watching ________	**….**thinking ________	**….**doing ________
5	**When I learn….**	**….**I am open to new experiences ________	**….**I look at all side of an issue ________	**….**I like to analyze, think, break them into their parts ________	**….**I like to try thinks out ________
6	**When I am learning….**	**….**I am an intuitive person ________	**….**I am an observant person ________	**….**I am a logical person ________	**….**I am an active person ________
7	**I learn best from ….**	**….**personal relationships ________	**….**observation________	**….**rational theories ________	**….**a chance to try and practice________
8	**When I learn ….**	**….**I feel personally involved ________	**….**I take my time before acting ________	**….**I like ideas and theories ________	**….**I like to see result from my work ______
9	**I learn best when….**	**….**I rely on my feelings ________	**….**I rely on my observations ________	**….**I rely on my ideas ________	**….**I can try things out for myself ________
10	**When I am learning….**	**….**I am an accepting person ________	**….**I am a reserved person ________	**….**I am a rational person ________	**….**I am a responsible person ________
11	**When I learn….**	**….**I get involved ________	**….**I like to observe ________	**….**I evaluate things ________	**….**I like to be active ________
12	**I learn best when….**	**….**I am respective and open-minded ________	**….**I am careful ________	**….**I analyze ideas ________	**….**I am practical ________
Total					

APPENDIX-B

KOLB’S LEARNING STYLE INVENTORY (LSI)-ARABIC VERSION

<u>قائمةأنماط التعلم لكولب</u>

صممت هذه القائمه من أجل الكشف عن انماط التعلم لدى طلبة الصفين الخامس والسادس، وهي مكونه من 12 فقره لكل فقره ارع خيارات مختلفه . أرجو ترتيب هذه الفقرات من 1 الى 4 في الفراغ المخصص (ـــــــ) حسب ما تعتقد انها تتناسب مع كيفية تعلمك لموضوع ما.

ضع العدد 4 للفقرة الأكثر تفضيلا" بالنسبة لك
ضع العدد 3 للفقره ذات التفضيل الثاني بالنسبة لك
ضع العدد 2 للفقرة ذات التفضيل الثالث بالنسبة لك
ضع العدد 1 للفقرة الاقل تفضيلا بالنسبة لك

<u>الزمن : 10 دقائق فقط</u>

1	عندما أتعلم أحب أن -----	اتبع احاسيسي _______	أستمع واراقب ما حولي ____	أفكر وأتمعن بالافكار المختلفه________	اقوم بأداء الاعمال_______
2	أتعلم بشكل افضل عندما -------	أثق بمشاعري وافعالي بشكل كبير________	أستمع واراقب بشكل جيد________	أعتمد على التفكير المنطقي_______	أعمل باجتهاد لانجاز الاعمال المطلوبه________
3	عندما أتعلم -----	أكون نشيط ومتحمس ________	أكون هادىء ومتحفظ ________	أميل الى معرفة الاسباب المختلفه ________	أكون مسؤولا" عن أعمالي________
4	أتعلم من خلال --------	المشاعر________	المراقبة والملاحظه ________	التفكير ________	العمل ________
5	عندما أتعلم --------	أكون متقبلا" لكل التجارب الجديده_______	أحب التمعن والنظر في الجوانب المختلفه ________	أحب تحليل وتفكيك الافكار الى أجزاء مختلفه________	أحب أن اقوم بتجريب الاشياء المختلفه ________
6	عندما أتعلم احب أن------	أتبع أحاسيسي ________	اراقب والاحظ ________	اكون منطقيا" ________	أكون فعالا"________
7	أتعلم بشكل أفضل من خلال --------	العلاقات الشخصيه ________	ملاحظاتي ________	النظريات المنطقية والعقلانيه _______	المحاولة والتدريب________
8	عندما أتعلم أحب - ------	أن اشارك شخصيا" ____	أن آخذ وقتا" كافيا قبل التصرف _______	الأفكار والنظريات ______	رؤية نتائج اعمالي ______
9	أتعلم بشكل أفضل عندما أعتمد --------	على مشاعري ________	على ملاحظاتي ________	أفكاري ________	على تجريب الأشياء بنفسي ________
10	عندما أتعلم -------	أتقبل ألآخرين ________	أكون شخصا" متحفظا" ________	أكون شخصا" عقلانيا" ________	أكون شخصا" مسؤولا عن أفعالي ________
11	عندما أتعلم أحب أن -----	أشارك ________	أراقب ________	أقيم ________	أكون فعالا"______
12	أتعلم بشكل أفضل عندما --------	أكون منفتحا" ومتقبلا" للآخرين_______	أكون حريصا" ________	أحلل الأفكار المختلفه ________	أكون عمليا" ________
المجموع					

APPENDIX- C

MATHEMATICS DIAGNOSTIC TEST- ENGLISH VERSION

Mathematics Diagnostic Test

School		Grade:
Date		

This test is designed to explore systematic patterns of errors made by the two grades five and six students on dividing fractions. This test will evaluate your knowledge of fractions and diagnosis the weak areas. Your result on this test will not effect on your mathematics score in school.

Instructions:-

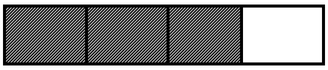
1. Write the name of your school, and your grade before start answering this test.
2. Calculators are not permitted to be used in any part of this test.
3. Show your work when it is required.
4. Scrape paper is not permitted; use the pack side of the test booklet.
5. All work should be done in pencil.
6. This test contains two sections, with 20 questions. You have to solve all questions in this booklet

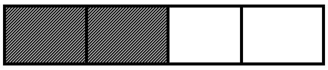
Test Duration 25 minutes

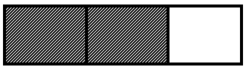
Section (1): Concepts

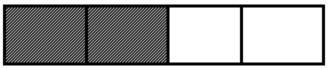
<u>Circle the correct answer in questions: 1-15</u>

1) Find $\frac{3}{5}$ in below

a) 

b) 

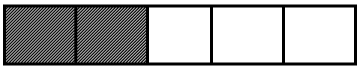
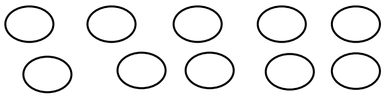
c) 

d) 

2) Find the missing numbers in the two fractions

$$\frac{5}{\bigcirc} = \frac{10}{14}, \quad \frac{3}{7} = \frac{\bigcirc}{21}$$

3) Use the figure on the right to represent an equivalent fraction to the one presented on the left.

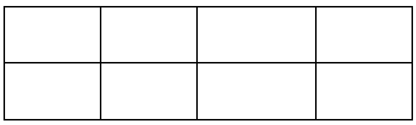
 

4) Which fraction in the following is the biggest?

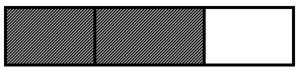
$$\frac{1}{2}, \frac{5}{6}, \frac{100}{400}$$

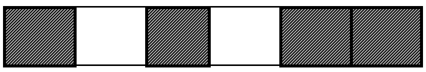
5) 4 girls share 3 pencils and 5 boys share 2 pencils. Who gets more pencils, a girl or a boy?

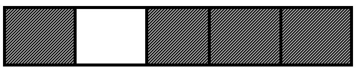
6) Shade five-eighths in the following figure

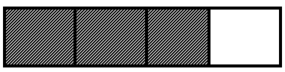


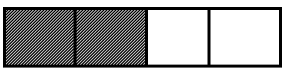
7) Which of the following is equivalent to the fraction?



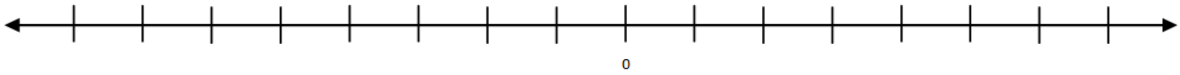
a) 

b) 

c) 

d) 

8) Show the fraction $\mathbf{\frac{5}{2}}$ on the number line below?



9) Which of the following fractions is equivalent to $\frac{4}{5}$?

$a)\frac{16}{20}$ $b)\frac{9}{10}$ $c)\frac{4}{10}$ $d)\frac{8}{15}$

10) The fraction $\frac{9}{4}$ is equal to

$a)2$ $b)1\frac{5}{4}$ $c)4\frac{1}{2}$ $d)2\frac{1}{4}$

11) Which one of the following statements is correct?

$a)\frac{2}{5} > \frac{3}{4}$ $b)2\frac{1}{2} \prec 1\frac{9}{10}$ $c)\frac{12}{18} \prec \frac{5}{6}$ $d)\frac{3}{5} > \frac{5}{8}$

12) Which of the following represents the fraction $\frac{3}{4}$?

$a)3 \times 4$ $b)4 \div 3$ $c)3 \div 4$ $d)3.4$

13) $6 \div 12 =$

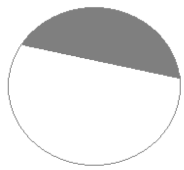
$a)12$ $b)3$ $c)\frac{1}{2}$ $d)5\frac{1}{2}$

14) The fraction in lowest terms that represent sharing 17 Dhs. between 4 students is?

$a)4$ $b)\frac{4}{17}$ $c)\frac{17}{4}$ $d)4\frac{1}{4}$

15) The following figure is a representation of the fraction $\frac{1}{2}$

a) Yes b) No



Section (2): Division (Show your work)

<u>Solve the following. Put your answer in lowest terms</u>

1) $\mathbf{1 \div \frac{1}{2} =}$

2) $\mathbf{\frac{1}{4} \div \frac{1}{2} =}$

3) $\mathbf{\frac{1}{5} \div \frac{2}{5} =}$

4) $\mathbf{\frac{3}{4} \div \frac{2}{3} =}$

5) $\mathbf{\frac{5}{6} \div 5}$

APPENDIX-D

MATHEMATICS DIAGNOSTIC TEST-ARABIC VERSION

اختبار تشخيصى لمادة الرياضيات

المدرسه	
الصف	
الحلقه	
التاريخ	

صمم هذا الاختبار من أجل الكشف عن أنماط اخطاء طلبة الصفين الخامس والسادس في قسمة الكسور في المدارس الحكومية التابعة لمجلس ابوظبي للتعليم ، علما" بأن نتيجة هذا الاختبار لن تؤثر على نتيجة الطلبه في مادة الرياضيات .

تعليمات:

1) **أرجوا تعبئة الجدول قبل البدء في الاجابة عن اسئلة الاختبار**
2) **لا يسمح باستخدام الآله الحاسبه في اي جزء من اجزاء الاختبار**
3) **يجب كتابة الحل عندما يطلب ذلك**
4) **يجب الاجابه عن جميع الاسئله**
5) **الاختبار مكون من 20 سؤال**

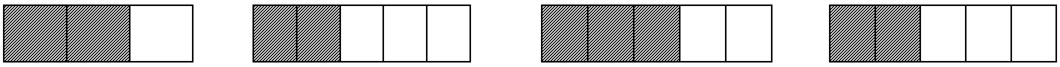
مدة الاختبار 25 دقيقه فقط

مع الشكر والتقدير لكل من ساهم في انجاز هذا البحث

<u>**الجزء الاول : المفاهيم**</u>

<u>**في الاسئله من 1-15 ضع دائره حول رمز الاجابه الصحيحه**</u>

1) الشكل الذي يمثل الكسر $\frac{3}{5}$ **هو**

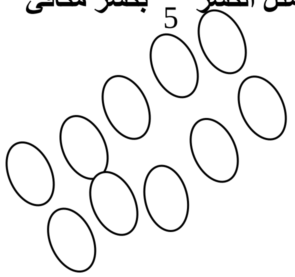


(a) (b) (c) (d)

2) املأ الفراغ في كل من الكسرين

$\frac{3}{7}=\frac{}{21}$, $\frac{5}{}=\frac{10}{14}$

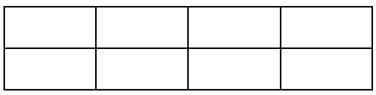
3) باستخدام الشكل التالي مثل الكسر $\frac{2}{5}$ **بكسر مكافئ**



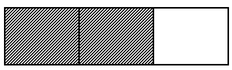
4) ضع دائرة حول الكسر الاكبر في الكسور التاليه: $\frac{1}{2}, \frac{5}{6}, \frac{100}{400}$

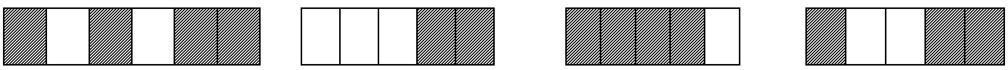
5) اذا تشارك اربع طالبات في ثلاثة اقلام و خمسة طلاب في قلمين من الذي حصل على عدد اكبر من الاقلام الطالب ام الطالبه ، وضح اجابتك.

6) ظلل خمسة اثمان الشكل المجاور



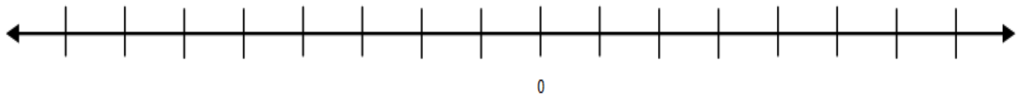
7) أي من الكسور التاليه يساوي الكسر





(a) (b) (c) (d)

8) حدد مكان الكسر $\frac{5}{2}$ على خط الأعداد التالي



9) أي الكسور التالية هو كسر يكافئ الكسر $\frac{4}{5}$

$a)\ \frac{16}{20}$ $b)\ \frac{9}{10}$ $c)\ \frac{4}{10}$ $d)\ \frac{8}{15}$

10) ان الكسر $\frac{9}{4}$ يساوي

$a)\ 2$ $b)\ 1\frac{5}{4}$ $c)\ 4\frac{1}{2}$ $d)\ 2\,\frac{1}{4}$

11) أي العبارات التاليه صحيحة

$a)\ \frac{2}{5} > \frac{3}{4}$ $b)\ 2\frac{1}{2} \prec 1\frac{9}{10}$ $c)\ \frac{12}{18} \prec \frac{5}{6}$ $d)\ \frac{3}{5} > \frac{5}{8}$

12) أي الاجابات التاليه يمثل الكسر $\frac{3}{4}$

$a)\ 3\times4$ $b)\ 4\div3$ $c)\ 3\div4$ $d)\ 3.4$

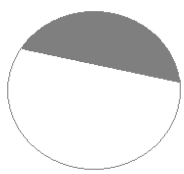
13) $6\div12=$

$a)\ 12$ $b)\ 3$ $c)\ \frac{1}{2}$ $d)\ 5\frac{1}{2}$

14) اذا أردنا توزيع 17 درهما بين 4 طلاب فان الكسر الذي يمثل عملية القسمه في ابسط صوره هو:

$a)\ 4$ $b)\ \frac{4}{17}$ $c)\ \frac{17}{4}$ $d)\ 4\,\frac{1}{4}$

15) الشكل المجاور يمثل الكسر $\frac{1}{2}$



لا **نعم**

الجزء الثاني : قسمة الكسور (أرجو كتابة طريقة الحل)

أوجد ناتج القسمه و ضعه في ابسط صوره

1) $1 \div \frac{1}{2} =$

2) $\frac{1}{4} \div \frac{1}{2} =$

3) $\frac{1}{5} \div \frac{2}{5} =$

4) $\frac{3}{4} \div \frac{2}{3} =$

5) $\frac{5}{6} \div 5 =$

APPENDIX-E

ABU DHABI EDUCATION COUNCIL (ADEC) APPROVAL LETTER

مجلس أبوظبي للتعليم
Abu Dhabi Education Council
Education First التعليم أولاً

التاريخ :2012/02/1
الرقم: 12

السادة/ مدراء المدارس الحكومية في أبوظبي الافاضل

الموضوع: تسهيل مهمة باحث

يطيب لنا أن نهديكم أطيب التحيات.

ونود إعلامكم بموافقة مجلس أبوظبي للتعليم على موضوع الدراسة التي سيجريها الباحث/ يوسف محمود ابو سالم بعنوان " العلاقة بين اساليب التعليم ما بين طلاب الصف الخامس والصف السادس في المدارس الحكومية في امارة ابوظبي " بناء على نموذج كولب ".

لذا يرجى التكرم بتسهيل مهمة الباحث ومساعدته على إجراء الدراسة.

شاكرين حسن تعاونكم

محمد سالم محمد الظاهري
المدير التنفيذي لقطاع العمليات المدرسية

مجلس أبوظبي للتعليم
قطاع العمليات المدرسية
Abu Dhabi Education Council
School Operations Sector

APPENDIX-F

THE BRITISH UNIVERSITY IN DUBAI (BUID) APPROVAL LETTER

The British University in Dubai

23 October 2011

Abu Dhabi Educational Council
Abu Dhabi
United Arab Emirates

This is to certify that Mr. **Yousef Abosalem Student ID: 90015** is a registered student on the **Doctorate of Education programme** in **The British University in Dubai** since September 2009.

Mr Abosalem is required to collect data from Abu-Dhabi schools for his doctoral study. We request you to assist him so he can proceed with his research and observations.

This letter is issued on Mr. Abosalem's request.

Yours sincerely,

Nandini Uchil
Head of Student Administration

www.buid.ac.ae | P O Box 345015, Block 11, 1st & 2nd Floors, Dubai International Academic City, Dubai, United Arab Emirates
Tel. +971 4 391 3626, Fax +971 4 366 4698

APPENDIX-G

CONSENT FORM-ENGLISH VERSION

Consent Form

Title of the study: The relationship between the two grades five and six students learning styles based on Kolb's model and making misconceptions on dividing fractions.

Invitation to Participate: I am inviting your son to participate in the above-mentioned research conducted by Yousef M. Abosalem, DED student, Faculty of Education, British University in Dubai yousef94@hotmail.com

This study will be conducted under the supervision of Prof. Lynne Pachnowski/ Akron University/ faculty of education and Dr. Sufian Forawi /Faculty of Education/British University in Dubai lmp@uakron.edu , sufian.forawi@buid.ac.ae

Purpose of the Study: This study will try to find out the learning styles preference of the two grades five and six students in Abu Dhabi according to Kolb's model of learning (1985) and thereby investigate if there is a statistical relationship between these learning styles and held misconceptions on dividing fractions.

Participation: The participants of this study are students of fifth and sixth grades in Abu Dhabi in both public and private schools.

Risks: Your son participation in the research will entail that he will answer a questionnaire and set for a mathematics test about dividing fractions, which might increase his anxiety caused by the test. I have received assurance from the researcher that every effort will be made to minimize these risks by minimizing the anxiety level and by assuring that your son's result on this test will not affect on his mathematics result in school.

Benefits: My participation in this study will help the mathematics teachers, curriculum designer in preparing mathematics curriculum in future and to help the students to direct their learning into a way that will help them in overcome the patterns of errors and misconceptions they might do.

Confidentiality and anonymity: I have received assurance from the researcher that the information I will share will remain strictly confidential. I understand that the contents will be used only for Yousef's research and that your son's confidentiality will be protected by replacing all personal details by a code number and keep all personal information in a closed place.

Conservation of data: The data collected, test's booklets, students' responses to the test and to the questionnaire will be kept in a secure place and it will be accessed by Yousef, Prof. Lynne Pachnowski and Dr. Sufian Forawi only .All information gathered by the researcher will be destroyed after 10 years.

Compensation: All schools participate in this study will be qualified to get a recognition letter at the end of the test and the questionnaire.

Voluntary Participation: I am under no obligation to participate and if I choose to participate, I can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences. If I choose to withdraw, all data gathered until the time of withdrawal will be destroyed in front of the participants.

Acceptance: I, ___________________________________ agree to participate in the above research study conducted by Yousef M. Abosalem of the Faculty of Education at British University in Dubai (BUID), which is under the supervision of Prof. Lynne Pachnowski and Dr. Sufian Forawi

If I have any questions about the study, I may contact the researcher or her/his supervisor.

If I have any questions regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, British University in Dubai (BUID) Block 11, first and second floor, Dubai International Academic City. P.O. Box: 345015, Dubai/UAE.

Tel: 00971 4391 3626

Fax: 00971 4366 4698

There are two copies of the consent form, one of which is mine to keep.

Participant's signature: ________________________________ Date: _________________

Researcher's signature: ________________________________Date:__________________

APPENDIX-H

CONSENT FORM-ARABIC VERSION

عدم ممانعة من المشاركة في دراسة

عنوان الدراسه: العلاقة بين انماط التعلم لدى طلبة الصفين الخامس والسادس حسب قائمة كولب وأخطائهم في قسمة الكسور

دعوة للمشاركين في الدراسه: أرجو التكرم بالموافقه على الشاركة في الدراسه اعلاه والتي يقوم باجرائها والذي يدرس في برنامج الدكتوراه في الجامعه yousef94@hotmail.com**الطالب يوسف محمود أبوسالم البريطانيه في دبي / كلية التربيه.**

علما بان هذه الدراسه سوف تجرى تحت اشراف كل من البرفوسور لين باشونسكي من جامعة اكرون / اوهايو من الجامعة البريطانيه في lmp@uakron.edu , sufian.forawi@buid.ac.ae**والدكتور سفيان فوراوي دبي كلية التربية.**

هدف الدراسه: تهدف هذه الدراسه الى محاولة معرفة انماط التعلم لدى طلبة الصفين الخامس والسادس في المدارس الحكومية التابعة لامارة أبوظبي حسب قائمة كولب للتعلم واكانية وجود علاقة ذات دلاله احصائيه بين هذه الانماط والاخطاء المفاهيمية لديهم في عملية قسمة الكسور.

المشاركون في الدراسه: طلبة الصفين الخامس والسادس في المدارس الحكوميه التابعة لامارة ابوظبي.

المخاطر الناجمه عن المشاركه في الدراسه: سوف يقوم الطالب المشارك في هذه الدراسه بالاجابه على استبيان مكون من 12 فقره وايضا الاجابه على اختبار تشخيصي في مادة الرياضيات / قسمة الكسور. أن المشاركه في هذه الدراسة من المحتمل ان تؤدي الى زيادة مستوى التوتر والقلق لدى الطالب اثناء الاجابه عن الاختبار والاستبيان. وقد تم تقديم تعهد من الباحث بأن يبذل جهده في تخفيض مستوى القلق والتوتر من خلال التأكيد ان المشاركه في الدراسه لن تؤثر في حالة من الاحوال على نتيجة الطالب في مادة الرياضيات في المدرسه.

الفائدة من الدراسه: ان المشاركه في هذه الدراسه من شأنه ان يساعد معلمي الرياضيات، وواضعي المناهج في المستقبل على توجيه طريقة تعلمهم للعمل على التقليل من الاخطاء المفاهيميه التي من الممكن أن يقع فيها الطلاب.

الخصوصيه والسريه: لقد تم التأكيد من قبل الباحث ان جميع المعلومات التي سوف يتم جمعها في هذه الدراسه سوف يتم التعامل بها بسرية تامه ، وان هذه المعلومات سوف يتم استخدامها من قبل الباحث فقط وسوف يتم ترميز كل المعلومات الشخصيه الخاصة بالطالب المشارك في هذه الدراسه وسف يتم حفظها بمكان سري ومغلق.

حفظ البيانات: ان كل البيانات التي سوف يتم جمعها في هذه الدراسه سواء اجابة المشارك على الاختبار او على الاستبانه سوف تحفظ بمكان آمن ويسمح فقط لكل من الباحث والبرفوسور لين والدكتور سفيان باستعراضها وسوف يتم حذف جميع المعلومات واليانات المجمعة بعد عشر سنوات من تاريخ جمعها.

الحوافز: سوف يتم منح كل مدرسة شاركت في هذه الدراسة رسالة شكر وتقدير من الباحث لمساهمتهم في تطبيق هذه الدراسه.

خيارية المشاركة: بدون أي أدنى مسؤولية نتيجة المشاركه في هذه الدراسه واحتفظ بحقي في أي وقت بالانسحاب من الدراسه أو رفض الاجابه عن أي سؤال او فقرة بدون تحمل أي مسؤولية أو عواقب نتيجة ذلك

الانسحاب . وفي حالة قراري الانسحاب من هذه الدراسه سوف يتم حذف كل البيانات التي تم جمعها حتى تاريخ الانسحاب امام الطالب المشارك في الدراسه.

الموافقة: أنا اوافق على المشاركه في هذه الدراسه والتي يقوم بها الباحث يوسف ابوسالم من كلية التربيه في الجامعة البريطانيه في دبي تحت اشراف كل من البرفوسور لين باشونسكي من جامعة اكرون / اوهايو والدكتور سفيان فوراوي .

في حالة وجود أي سؤال يتعلق في هذه الدراسه من الممكن الاتصال مع الباحث أو المشرفين عليها.

في حالة وجود أي شائبه احلاقية ناتجة من تطبيق هذه الدراسه ، من الممكن الاتصال مع المكتب المسؤول عن اخلاقية البحث في الجامعة البريطانيه في دبي على العنوان التالي:

مدينة دبي الجامعيه / بناية رقم 11 الطابقين الاول والثاني

صندوق بريد : 345015 / الامارات / دبي

تلفون : 0097143913626

فاكس : 0097143664698

يوجد نسختين من هذا النموذج ، احدهما تبقى مع المشارك في هذه الدراسه

توقيع المشارك في الدراسه: التاريخ:

توقيع الباحث : التاريخ:

APPENDIX-I

ETHICS FORM

NAME OF RESEARCHER: YOUSEF MAHMOUD ABOSALEM

CONTACT TELEPHONE NUMBER: +971-508289443

EMAIL ADDRESS: yousef94@hotmail.com

DATE: 12 September, 2011

PROJECT TITLE:

The relationship between grade five and six students' learning styles based on Kolb's model and misconceptions on dividing fractions.

BRIEF OUTLINE OF PROJECT (100-250 words; this may be attached separately. You may prefer to use the abstract from the original bid):

This study will try to find out the learning styles preference of the two grades five and six students in Abu-Dhabi according to Kolb's model of learning and thereby investigate if there is a statistical relationship between these learning styles and making misconceptions on dividing fractions. In order to find out students learning styles preference, Kolb's Learning Style Inventory version-3 (1999) will be used as a data collection instrument. The inventory consists of four basic categories of learning styles with twelve incomplete statements, each of them with four possible completion phrases. Additionally, it will try by using a diagnostic mathematics test to find out students' misconceptions on dividing fractions. Lastly, it will try to investigate if there is a significant relationship between students' learning styles and making misconceptions on dividing fractions

MAIN ETHICAL CONSIDERATION(S) OF THE PROJECT (e.g. working with vulnerable adults; children with disabilities; photographs of participants; material that could give offence etc):

Since the study's subjects are students of the two grades five and six, and they are minors, All study participants' guardians will be asked to sign a consent form (Appendix- B) to confirm their permission to let their kids participate in the study. Each student will be kept anonymous; all information gathered from the subjects will be kept confidential, the researcher and the advising committee will have access to datasets

The participants will be asked to answer a 12 items questionnaire and to set for a mathematics diagnostic test about dividing fractions, which might increase their anxiety caused by the test. Every effort will be made to minimize these risks by minimizing the anxiety level and by assuring that the subjects' result on this test will not affect on his mathematics result in school.

DURATION OF PROPOSED PROJECT (please provide dates as month/year):

After I obtained both BUID and Abu Dhabi Education Council (ADEC) approvals to conduct the study, I will start the data collection process. Therefore, the project might finish hopefully by October 2012. Details of the project are shown below:

October

• Proposal defense	• Modify the proposal according to the DOS comments and suggestions	• Complete literature review

November-January

• Get ADEC approval to conduct the study in Abu Dhabi schools • Conduct a pilot study to test the data collection instruments' reliability	• Complete data collection	• Data analysis

February-March

• Complete data analysis and interpretations	• Begin thesis first draft

April- October

• Complete thesis first draft	• Discuss thesis first draft with supervisor	• Thesis second draft	• Thesis second draft	• Proofing/ checking

DATE YOU WISH TO START DATA COLLECTION:

Last week of April and May, 2012

Please provide details on the following aspects of the research:

1. What are your intended methods of recruitment, data collection and analysis?

Please outline (100-250 words) the methods of data collection with each group of research participants.

The data will be collected by using two data collection instrument. The first one will be Kolb's Learning Style Inventory (LSI) which consists of 12 items. As well as, a mathematics diagnostic test will be used to find out students' misconceptions on dividing fractions. The test will be three parts. The first part will consist of demographic information such as gender, age, and school type (private or government). The second part will be a multiple choice question about fractions' concepts such as fraction's parts (Numerator and denominator) changing from improper fraction to mixed numbers and vies versa. Last part will be problem solving questions, the students will be asked to show their work in details in order to find out their misconceptions.

The population of this study including the fifth and sixth grades students in Abu-Dhabi schools $(N = 9553\ students)$ distributed into 31 schools with 381 classes.

Therefore, a representative and efficient cluster sample, which uses clusters (schools) rather than single unit elements (students) that are randomly selected, will be employed with the same characteristics of the population. The schools will be given random numbers from 1 to 31, every third school will be selected which will give a total number of 10 schools .All grades five and six students in the selected schools will be asked to participate in the study.

2. How will you make sure that all participants understand the process in which they are to be engaged and that they provide their voluntary and informed consent? If the study involves working with children or other vulnerable groups, how have you considered their rights and protection?

In order to make sure, that students understand and comprehend the aims of the study and the ethical issues related to it. As I did mention above, all students' guardians will be asked to sign a consent form to confirm that their kids are willing to participate in the study. Before starting administering the two data collection instruments in classes, I will clarify personally with the help of mathematics teachers and schools' managements all instructions that will be needed to get accurate information and minimize all risks if there is any.

3. How will you make sure that participants clearly understand their right to withdraw from the study?

With the help of guardians, mathematics teachers and schools' managements, I will clarify to them before filling up the questionnaire and solving the mathematics test that they are free to quit at any time without any justification and without any consequences. Moreover, they will be informed that they have all rights to withdraw from the study even after they answered the mathematics test and fill up the questionnaire either by contacting me through their guardians, directly, my thesis advisor or BUID ethical board.

4. Please describe how you will ensure the confidentiality and anonymity of participants. Where this is not guaranteed, please justify your approach.

In order to maintain the confidentiality and anonymity of participants, each school engaged in the study will be given a code number for further investigation if it is needed. Additional all students will be given a code number mentioned on the two data collection instruments to track their responses on them without mentioning their names or any personal details that might violate the confidentiality and students anonymity.

5. Describe any possible detrimental effects of the study and your strategies for dealing with them.

As I did mention above in the ethical issues, the only effect of this study will be the anxiety level since the students will be asked to set for a mathematics test. In order to deal with this effect, they will be informed that their score in the test will not affect their grades in schools, and they will be informed that none of their mathematics teachers or school managements will be able to see or get accessed to their responses on the two data collection instruments.

6. How will you ensure the safe and appropriate storage and handling of data?

The data collected, test's booklets, students' responses to the test and to the questionnaire will be kept in a secure place and the researcher and thesis advisor only will access it. All information gathered by the researcher will be destroyed after 10 years.

7. If during the course of the research you are made aware of harmful or illegal behavior, how do you intend to handle disclosure or nondisclosure of such information (you may wish to refer to the BERA Revised Ethical Guidelines for Educational Research, 2004; paragraphs 27 & 28, p.8 for more information about this issue)?

8. If the research design demands some degree of subterfuge or undisclosed research activity, how have you justified this?

Not applicable since the data that will be collected from the subjects consist of their responses on a mathematics test and fill up a questionnaire.

9. How do you intend to disseminate your research findings to participants?

After the completion of this project and has approved by the thesis committee, all schools participating in the study will be provided by a thesis copy. As well as, they will be provided by a short report describing their students' results in order to help the students of the two grades engaging in the study to overcome or minimize their misconceptions on dividing fractions, and helping teachers to direct their instructions to match their students' learning styles.

Declaration by the researcher

I have read the University's Code of Conduct for Research and the information contained herein is, to the best of my knowledge and belief, accurate.

I am satisfied that I have attempted to identify all risks related to the research that may arise in conducting this research and acknowledge my obligations as researcher and the rights of participants. I am satisfied that members of staff (including myself) working on the project have the appropriate qualifications, experience and facilities to conduct the research set out in the attached document and that I, as researcher take full responsibility for the ethical conduct of the research in accordance with the Faculty of Education Ethical Guidelines, and any other condition.

Print name: Yousef Mahmoud Abosalem

Signature:

Date: 12 September 2011

Declaration by the Chair of the School of Education Ethics Committee (only to be completed if making a formal submission for approval)

The Committee confirms that this project fits within the University's Code of Conduct for Research and I approve the proposal on behalf of BUiD's Ethics Committee.

Print name:

(Chair of the Ethics Committee)

Signature:

Date: