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# Effects of the know-want-learn strategy on students' mathematics achievement, anxiety and metacognitive skills

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**Abstract** This study was conducted in order to examine the effects of the Know-Want-Learn (KWL) strategy on 6th graders' mathematics achievement, metacognitive skills and mathematics anxiety. A pretest-post test control group quasi- experimental design was used in the study. The sample of the study was composed of 55 6th graders attending public elementary schools. The data have been collected by administering the "Math Achievement Test", "Metacognition Inventory" and the "Math Anxiety Scale". The "KWL strategy" was used in teaching mathematics to the study group whereas the control group was taught using the "traditional method". The results of the study showed that employing the "KWL strategy" in 6th grade mathematics can be effective in increasing achievement and metacognition while it was no efficient than the traditional method regarding the reduction of anxiety.

**Keywords** Metacognition · Mathematics achievement · Math anxiety · KWL strategy

## Introduction

Mathematics is very important matter throughout human life. Today's pupils will all need mathematics when they leave school and get a job. Without an understanding of mathematics, they will be disadvantaged throughout their lives (Hannell 2007). The body of mathematical knowledge refers to the skills, concepts, strategies and techniques that are often taught before a pupil engages in the application of this knowledge in a real-life context or open-ended problem solving situation (Cowan 2006).

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## Theoretical framework

### *Reading and mathematics*

Reading and mathematics are two skills people of various ages use simultaneously as well as daily in their lives. Students who cannot read or struggle with reading and comprehending mathematics textbooks are likely to have greater trouble grasping difficult mathematical concepts (Helm 2005). Mathematicians would wholeheartedly acknowledge that mathematics remains a mystery to many of today's students. These students do not understand the significant role that mathematics plays in their adult lives, and they rarely see the link between reading and mathematics (Brummer and Macceca 2008). They often think that mathematics involves only numbers, abstract symbols, and their interrelationships; they forget that mathematics involves natural thought and language processes as well. For them, reading happens in English classrooms, not in mathematics classrooms (Fuentes 1998). By continually applying appropriate reading strategies to mathematics, students are able to bridge the gap between the two constructs, and ultimately, unite them for a better understanding of both (Brummer and Macceca 2008).

Many teachers, like their students, still think of mathematics as a totally separate subject from language arts. They may not see the connections to what students are learning during reading and writing instruction or if they do, they may not know how to make those math-literacy connections explicit or use them effectively (Fogelberg et al. 2008). In order to enable students to establish these connections reading strategies should be applied and the reading strategy used in this study is called the Know-Want-Learn (KWL).

### *The KWL strategy*

KWL is a simple and yet very powerful reading strategy (Foote et al. 2001) that is helpful in almost all classrooms, in any subject area (Brozo and Simpson 1991). The theoretical basis of this part of the KWL strategy is based on the schema theory. As students access their schema about a given topic, they combine new information with previously learned information (Jared and Jared 1997, p.26). According According to Piper (1992) the KWL technique is a common method used by teachers to help students activate their schema prior to reading, improve comprehension during reading, and organize their thoughts following reading. Moreover, this strategy has been designed to ensure that the reader makes a connection between knowledge received from the reading process and previous knowledge, organize the knowledge, unify it, and summarize it (Headley and Dunston 2000; Garkins and Jones 1992).

Ogle (2009) has devised the KWL strategy as a graphical organizing instrument in order to encourage research and inquiry in students. The KWL strategy takes the students' questions as the starting point and in that it agrees with Ogle Piaget's idea of "cognitive disequilibrium is needed for learning to begin." This strategy directly applies to the constructivist learning theories in which learners "individually discover and transform complex information" and make it their own (Slavin 2003, p. 257). According to Ogle (2005, p.64) "teachers need to employ classroom instructional studies that facilitate students' construction of their own meanings. KWL provides a framework for learning that can be used across content areas to help students become active constructors of meaning". As Draper (2002) stated that comprehension activities such as KWL give teachers a structure with which to support learning and enable them to create a student-centered, constructivist classroom.

KWL strategy is one which is based on the reader's knowledge on a subject, what the reader wants to know, and what the reader has learned at the end of the reading process and one in which the information is arranged graphically (Camp 2000). The KWL strategy is reader-centered, not author-centered (Pennington 2009).

In the KWL strategy the teacher and students begin the process of reading and learning by brainstorming together about what they *know* (the K in K-W-L) about a topic. The teacher guides students to probe their knowledge statements and to find conflicting or partial statements of what they know. The teacher writes on the blackboard, overhead projector, or computer what the students think they know, writing down their ideas just as they volunteer them. The teacher's role is not to correct or evaluate but to encourage and stimulate students to think broadly about what they bring to the study. With a variety of ideas being shared, the teacher can easily ask what the students *want to know* (the W in K-W-L). Again, it is the students' role to think of real questions, and the teacher's role to write down what they say. These questions form the second column on the worksheet or blackboard. Finally, they write what they have learned in an essay form, so they have additional opportunities to consolidate their learning (Blachowicz and Ogle 2008).

The KWL strategy allows the learner to bring to the surface prior knowledge by generating what is known about a topic (Banikowski 1999). According to Barton and Heidema (2000) "the importance of teachers activating and assessing students' prior knowledge in mathematics cannot be overstated. Strategies teachers can use to activate prior knowledge include KWL"(p.11). By activating prior knowledge, teachers help students understand the relationships between what they have previously learned and what they are currently learning. Additionally, activating prior knowledge helps students use mathematical vocabulary. The ability to understand vocabulary, both orally and in script, is essential for mathematical text comprehension, which requires the ability to understand the majority of the words encountered while reading (Carter and Dean 2006). After generating what is known, learners generate what they want to know–which is an excellent way to establish a purpose for learning. After learning, students generate what they have learned–an excellent way to compare prior knowledge which might have been erroneous, with new, accurate knowledge (Banikowski 1999).

KWL is an interactive approach to engaging students that fosters skill development and allows flexibility, freedom, and opportunity to cover curriculum matter in any field (Foote et al. 2001). This strategy can be used in a whole class activity, group activity or individual activity in order to help students remember what they have read, revise concepts and vocabulary, activate prior knowledge, and assess what students have learned at the end of the unit, subject or text (Camp 2000; Dobbs 2003; Martorella et al. 2005). The model is an organizational tool as it enables students to identify known information about a given subject. This identification allows for a more complete understanding of a topic as each student questions and researches a specific area of interest (Jared and Jared 1997).

According to Helm (2005), KWL is applicable to the mathematics classroom. In line with Ogle (1992; as cited in Fogelberg et al. 2008) also noticed charts in classroom listing steps for solving math problems. She found that many students could successfully transfer the math problem solving to their thinking about the stories they were reading. Ogle reports that both teachers and students were surprised to make this connection between math and literature, but once they noticed it, they readily applied it.

*Math achievement and the KWL strategy*

According to the 2003 and 2006 test results of PISA, which evaluates the mathematical skills of a total of 250 thousand 15 year old students from 41 countries including Turkey, Turkey has one of the lowest performances (OECD 2004; Eraslan 2009). As a result, Turkish students got one of the lowest scores in both 2003 and 2006 tests among the general standing including OECD countries (Eraslan 2009). According to these results derived from intercountry comparisons, the students can be taught effective learning strategies to increase their academic achievement (Üredi and Üredi 2005).

The KWL strategy can be used effectively to help scaffold the students' thoughts as they problem-solve in the early phases of problem-solving as it requires the students to consider what they know about a problem placed in front of them, what they need to know, and what they have already learned ('Sheltered Instruction' 2009). Within the same contex, KWL allows students to address the idea of learning as a metacognitive process. If students know how they learn best they will be more successful learners (Ogle 2005). Gammill (2006) too states that the KWL strategy gives a chance to learning and remembering.

Consequently, the results of the studies conducted on the KWL strategy demonstrate that it increases academic achievement and is effective in understanding what is being read (Al-Khateeb and Idrees 2010; Al-Shaye 2002; Hall 1994) in math classes (Larmon 1995; El-Rahman 2011), science classes (Akyüz 2004; Mclaughlin 1994; Reichel 1994), social studies classes (Cantrell et al. 2000; Piper 1992), and technology classes (Jared and Jared 1997).

*Metacognition and the KWL strategy*

Metacognition is important for learning mathematics (Nathan 2000). The concept of metacognition refers to "one's knowledge concerning one's own cognitive processes and products" (Flavell 1976, p.232). Classroom instruction frequently focuses on mathematical knowledge but neglects the role of metacognition in problem solving. However, instruction that emphasizes understanding problem meanings and monitoring strategy choices improves students' success as well as their ability to transfer these skills to less familiar problems. Students who are not used to thinking metacognitively sometimes resist having to do so, especially if they have been passive learners for many years (Gourgey 2004).

Metacognitive learning occurs whenever a person acquires some general strategy that facilitates learning or understanding knowledge. Ideally, the most powerful metacognitive learning would be the acquisition of strategies that apply at any grade level and to any subject matter (Novak 1990). Generally, poor readers are not aware that they must attempt to make sense out of text. When students become aware of their own learning processes, they can diagnose their needs and apply metacognitive strategies to eliminate their shortcomings (Guthrie 1983). Good learners tend to have good metacognitive strategies (Bruner 1996). The result of a study conducted by Maqsud (1998) which he taught metacognitive strategies to secondary school students in math classes shows that these strategies increased the academic achievement of students.

KWL is a metacognitive strategy because it is a problem solving process that focuses on thinking about and developing a language for the thinking (reading) process (Pennington 2009). The KWL method is designed to raise the awareness of learners and develop their metacognition (Mok et al. 2006). KWL serves several purposes: it helps students to determine their own purpose for reading and also it helps each student to monitor his/her comprehension (Szabo 2006). Various researchers have examined the effectiveness of KWL strategy on metacognitive awareness (Carr and Ogle 1987; Ogle 1986) and the results indicate that KWL strategy increased metacognitive awareness (as cited in Mclain 1993). For these reasons in this study KWL strategy is expected to be effective on metacognition.

*Math anxiety and the KWL strategy*

On the other hand, affective factors play a critical role in mathematics learning and instruction. Evidence of negative attitudes and high levels of anxiety toward mathematics is abundant (Herbert and Furner 1997). Math Anxiety is "the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" (Tobias and Weissbrod 1980, p.65). Many students, with or without mathematical disabilities, who perceive themselves as not good in mathematics develop a fearful avoidance of mathematical situations known as math anxiety (Wadlington and Wadlington 2008).

Math anxiety affects a significant number of students at various levels of education. This results in having students who are math avoidant in choosing school coursework, and therefore, affects future vocational options as well. Although treatments vary, the prevention of mathematics anxiety should be the primary concern for all teachers of mathematics at any level (Bonnstetter 1999).

Fewer than 30 % of students across the Organization for Economic Co-Operation and Development [OECD] agree or strongly agree with statements indicating that they get very nervous while solving mathematics problems; get very tense when they have to do mathematics homework or feel helpless when solving a mathematics problem. There is considerable cross-country variation in the degree to which students feel anxiety when dealing with mathematics, with students in France, Italy, Japan, Korea, Mexico, Spain, and Turkey reporting feeling most concerned. For example, half of the students in Turkey report that they get very tense when they have to do mathematics homework. 64 % of the students in Turkey report that they often worry that they will have difficulty in mathematics classes (OECD 2004).

Mathematics anxiety is a widespread problem in secondary and high school classrooms. Since math anxiety is widespread and the needier the understanding of mathematics is critical to success in school, the more practical classroom strategies secondary teachers need to use to relieve these anxious feelings in their high ability students (Herbert and Furner 1997). Learning strategies are considered to have their impact indirectly on warding off anxiety (Kanfer, Ackerman, & Heggestad; Kuhl, as cited in Warr and Downing 2000) and KWL as a learning strategy can have positive effects on math anxiety from this perspective. In addition, writing can also be a powerful tool in helping students overcome math anxiety (Johnson 2009). Since during the application of the KWL strategy, students write what they know about the subject, what they want to know, and what they have learned (Blachowicz and Ogle 2008). Accordingly, the KWL strategy can be considered as a tool in decreasing mathematics anxiety.

As a result, content area reading requires teachers to incorporate effective reading strategies into their discipline-specific instruction. The Principles and Standards for School Mathematics (NCTM 2000) encourages the incorporation of reading and support of reading skills to learn mathematics. Unfortunately, many mathematics teachers lack the essential training to teach reading strategies as well as the confidence to integrate literacy instruction into their mathematics classrooms (Barton, Heidema & Jordan; Bintz & Moore, as cited in Carter and Dean 2006). Elementary school teachers are responsible for providing students with the knowledge and strategies necessary for understanding and using mathematics (Fogelberg et al. 2008). Accordingly, many researchers have argued that traditional mathematics instruction emphasizes isolated computational skills at the expense of developing problem solving capabilities and mathematical thinking ability, and that it relies on authoritarian and impoverished forms of teaching (Romberg & Carpenter, as cited in Murphy 1998).

Metacognition has been identified in recent learning research as one of the most important factors affecting learning (Mok et al. 2006). Students with good metacognition demonstrate good academic performance compared to students with poor metacognition (Coutinho 2008). Furthermore, metacognition has been identified in recent learning research as one of the most important factors affecting learning (Mok et al. 2006). Cardelle-Elawar (1992) investigated the effects of metacognitive mathematics instruction on low-ability, mainly Hispanic, sixth graders and the authors concluded that lack of linguistic, strategic, and procedural knowledge was the major source of errors in solving problems. Pre and post-testing indicated that students receiving metacognitive instruction progressed as problem solvers. Desoete (2007) conducted a study on 32 children to investigate mathematical learning and metacognitive skills in grades 3 and 4. In addition, she described ways to enhance mathematics learning through metacognition. The results of this study showed that metacognitive skills need to be taught explicitly in order to improve and cannot be assumed to develop from freely experiencing mathematics. It might be possible that with more time allocated to metacognitive instruction, mathematics teaching-learning process may improve. In a study she conducted on private school students, Marge (2001) found that students who used a strategy in the mathematics classroom were more metacognitive, and accordingly, better at problem solving.

Additionally, Tobias proposed (as cited in Nathan 2000) that anxiety debilitates performance because its cognitive representation absorbs student cognitive processing capacity. Ineffective teaching techniques are often responsible for increasing math anxiety (Herbert and Furner 1997). Taking into account the complex nature of mathematical problem solving (Desoete 2007), employing different approaches such as the KWL strategy can have a positive effect on math achievement, metacognition, and math anxiety.

There is, however, little valuable research on KWL charts. Cantrell, Fusaro and Dougherty point out (as cited in Kass 2003) that there is a lack of scientific evidence supporting KWL. On the other hand, the study of mathematics problem solving from a metacognitive perspective is important because of the current status of children's mathematics skills (Santulli 1991). But, studies that measure the effects of the KWL strategy on math achievement (Larmon, as cited in Kass 2003; El-Rahman 2011) and metacognition (Witherspoon 1995; Mok et al. 2006) are limited and there is no research on this strategy's effect on mathematics anxiety. The purpose of this study, therefore, was to examine the effects of the KWL strategy on 6th grade students' mathematics achievement, metacognitive skills and mathematics anxiety.

The term mathematics achievement is operationally used to refer to problem solving including fractions, decimal fractions and ratio-proportion while the term metacognition is operationally used as cognitive strategies, planning, monitoring, self-checking, debugging, evaluation, awareness, information management strategies and procedural, conditional, and declarative knowledge. Also, the term math anxiety is operationally used as fear towards mathematics, stress, nervousness.

*Study hypotheses*

In order to study the problem, the following hypotheses were formulated:

1. There is a significant difference in the post-test score on the Math Achievement Test (MAT) between a group of sixth grade students who received KWL strategy instruction and group of sixth grade students who did not receive such instruction in favor of the treatment group.
2. There is a significant difference in the post-test score on the Metacognition Inventory (MI) between a group of sixth grade students who received KWL strategy instruction and group of sixth grade students who did not receive such instruction in favor of the treatment group.
3. There is a significant difference in the post-test score on the Math Anxiety Scale (MAS) between a group of sixth grade students who received KWL strategy instruction and group of sixth grade students who did not receive such instruction in favor of the treatment group.

## Method

### Research design

A pretest-post test control group quasi-experimental design was used in the study. Quasi-experiments do not use random assignment. In practice, it is often impossible in social research to assign subjects randomly to groups, particularly when the groups are pre-constituted (e.g. school classes, work departments, etc.) (Corbetta 2003, pp.107–108). Therefore, rather than randomly allocating, researchers will have to choose a control group that is as similar to the experimental group as possible (Muijs 2004, pp.27). In this pattern, two of the present groups are matched based on specific variables (Büyüköztürk et al. 2008). At the beginning of the experimental trial "Math Achievement Test", "Metacognition Inventory", and "Math Anxiety Scale" were administered in order to determine whether the groups were matching or not and the results of the t-test revealed that there was no significant difference ($p>.05$) between the pretest scores of the study groups. Whereas the KWL strategy was applied to the study group, the traditional method of teaching was applied to the control group. Finally, measurements related to the dependent variables of both groups were obtained by using the same tools.

### Subjects

The study was conducted with 55 (29 females) 6th graders attending a state elementary school in Hatay city's central county, Turkey. Students were aged 11–12 years and enrolled in two classes. A study group in which the KWL strategy was employed ($n=24$) and a control group ($n=31$) were designated randomly among these subjects.

### Data collection tools

Math Achievement Test, The Metacognition Inventory and Math Anxiety scale have been used as data collection tools in this research. Information on these tools is as follows:

*Math achievement test*

In this study, the mathematical achievement test covering the fractions, decimal fractions and ratio-proportion subjects has been developed by the researchers. During the development of this test firstly a table of specifications was formed within the framework of the set objectives (17 objectives) for the fractions, decimal fractions and ratio-proportion subjects in the Mathematics Course Curriculum for elementary 6th grade students and an experimental test of 45 questions was prepared based on experts' opinion. A total of 140 students attending a different state elementary school were given this test for the pilot study. The material analysis following the pilot study calculated each item's difficulty and discrimination indexes. Subsequently, a mathematics achievement test comprising a total of 30 questions was obtained. The means of the items in the test are between .29 and .90, and the standard deviations are between .40 and .50. The item total correlation coefficient ranges between .39 and .70. The test's KR-20 reliability coefficients were found to be 0.92. The math achievement test scores were organized in such a way that 1 point was given to the correct responses and 0 point for wrong responses.

Some of the questions covered by the mathematics achievement test are as follows:

1. Selin ate $\frac{2}{5}$ of 60 nuts. How many nuts did Selin eat in total?
2. Which order is true for the numbers 1,3 ; 1,03 ; 1,29 ?
3. $\frac{a}{2\times 5} = \frac{4}{7}$ What is the value of a in this proportion?

*Metacognition inventory*

The metacognition inventory that is internally consistent and valid in measuring metacognition devised by Çetinkaya and Erktin (2002) was used in the study. Items of the instrument are Likert-type, all scaled from 1 to 4 (1=Never, 4=Always). There are 32 items on the scale. Explatory factor analysis was conducted. The factor loadings of the inventory range between .30 and .62. Cronbach's alpha for the Metacognition Inventory (32 items) was 0.87

In order to observe the changes in attitudes, a validity and reliability study of the scale was conducted. To this end, this scale was applied on 137 6th graders. Afterwards, item-total analyses were made and items found to be under a value of 0.20 were removed from the scale. Principal component analysis with warimax rotation was applied on the remaining items to determine the construct validity of the instrument. Varimax rotation method was preferred due to the fact that it is more easily interpreted and often used in social sciences. Items with principal component analysis and varimax rotation values under 0.40 and items with a high factor loading which fell into two separate factors were discarded from the scale (Tavşancıl and Keser 2002). The 18 items left on the scale fall into one factor and their factor loadings changed between 0.444 and 0.907. The variance (extraction) of this factor is 47.7 % but after varimax rotation; it is 33.4 %. Since there are 18 items on the scale, the lowest point expected is 18, the highest is 72, and the range is 54. The mean of the scale is 53.5, the median is 54, the standard deviation is 7.30, and the skewness coefficient is −.354. These values show that the distribution of the scale is very close to normal distribution. The mean values of the items on the scale are between 2.51 and 3.38 and their standard deviation is between 0.73 and 0.97. The item-total correlation coefficients of the scale range between 0.22 and 0.56. Cronbach's alpha for the Metacognition Inventory (18 items) was 0.78

Some of the items in the this scale are: When I finish the study I try to learn as much as I can and understand what I have not; I can evaluate how much I have understood a subject; I try to understand what is being asked in exams before answering the questions; I check how I am doing while answering a question; I try to understand whether the exam questions are related to the subjects I know; I categorize the subjects while I study for exams; I am aware of the fact that I use specific methods to solve questions in an exam.

*Math anxiety scale*

The mathematics anxiety scale, whose validity and reliability have been proven and developed by Bindak (2005) for 7th graders, was also used in this research. The multidimensional five-point scale where 1=Never and 5=Always is used in the scale. Cronbach's alpha for the Math Anxiety Scale (10 items) was 0.84. The fact that the score is high points out to high levels of math anxiety. The results of the factor analysis that was applied in order to determine the construct validity of the scale show that the factor loadings of the 10 items range between 0.49 and 0.77 and that the items fall into one factor.

Since the subjects of the study were comprised of 6th graders, another validity and reliability study was conducted. Hence, the scale was applied on 137 6th graders. Then, an item-total analysis of the data obtained from the scale was made and one item with a value under 0.30 was removed from the scale. Principal component analysis with warimax was applied on the remaining items to determine the construct validity of the instrument. According to the results of this application, the 9 items remaining on the scale fall into one factor and their factor loadings range between 0.463 and 0.802. The variance (extraction) of this factor is 45.2 % but after varimax rotation; it is 30.7 %. Since there are 9 items on the scale, the lowest point expected is 9, the highest is 45, and the range is 36. The mean of the scale is 24.78, the median is 24, the standard deviation is 8.78, and the skewness coefficient is −.184. These values show that the distribution of the scale is very close to normal distribution. The mean of the items on the scale are between 1.84 and 2.80 and their standard deviation is between 1.15 and 1.48. The item-total correlation coefficients of the scale range between 0.55 and 0.80. Cronbach's alpha for the Math Anxiety Scale (9 items) was 0.86.

Some of the items in this scale are: I worry that I will always be asked questions in math classes; Math is so much fun for me; I do not fear anything than as much as I fear math exams; I am afraid of asking questions in math classes.

## Procedure

*Instructional materials used in the study*

Materials used by the study group included the KWL form, teacher's guide book, mathematics textbooks approved by the Ministry of Education, and test books. Material used by the control group included the same materials except the KWL form.

*Administering the pre-tests*

Math Achievement Test, The Metacognition Inventory and Math Anxiety Scale were administered as pre-tests to the study group and to the control group. The tests were given with 20 min rest intervals. The students were given 40 min to complete the mathematics achievement test and 15 min for the other two tests.

*Implementing the treatment*

The experimental procedures were conducted by two math teachers for 4 class hours a week, 32 class hours in total. The mathematics teacher of the study group had 5 years of experience while the teacher of the control group had 6 and both male. Units on "fractions, decimal fractions, and odd ratios" were taught to both the study group and the control group.

*Control group instruction*

The researcher informally observed the control group's mathematics class in order to have contact with the students and determine the type of mathematics instruction they received. Based on this informal observation of the class and discussions with the mathematics teacher, the researcher concluded that the control group received traditional mathematics instruction. The teacher focused on teaching the skills identified by the Ministry of Education for 6th graders. In the control group, instruction involved students' reading the problem silently, solving the problem individually, the teacher's checking the answers, a volunteer student's solving the problem on the board, and the correction of missing points and mistakes.

*Treatment group instruction*

First, the researcher gave the teacher of the study group KWL strategy training for 3 h. The teacher of the study group agreed to prepare lesson plans based on this strategy and employ the strategy for 8 weeks, four class hours a week. The researcher provided the teacher with a handout that described the KWL strategy and its integration into the lesson. Then the researchers met the study group in order to explain the KWL strategy and model a lesson based on the strategy. The mathematics teacher of the study group taught mathematics according to the lesson plans that he prepared based on the KWL strategy for 4 hours a week. The duration of each lesson hour was 40 min.

Some of the problems that the students worked on with the KWL strategy are:

1. Banu read 60 pages of a book. $\frac{5}{7}$ of the book remains to be read. How many pages does Banu's book have in total?
2. If a motor can siphon of 1200 lt of water in 3 h how many liters can it siphon off in 12 h?
3. In the equation of $\frac{x}{12}+\frac{1}{3}=\frac{7}{12}$ which natural number should replace x?

The activities that the study group's teacher carried out based on the KWL strategy can be listed as follows: The teacher presented the problem to the students in the first class (eg. Ali is 130 cm tall while his father is 170 cm tall. What is the ratio of Ali's height to his father's height?). Then the teacher drew the KWL chart on the board and guided the students through a brainstorm about what they knew about the problem and wrote student responses in the "what I know" section regardless of evaluating whether student responses were right or not. The students told what they know to the teacher making use of the oral/numeric symbols given within the problem and their previous experiences about this subject (eg. Ali is 130 cm tall and his father is 170 cm tall). Then, the teacher asked students to think about what they wanted to learn about the problem and wrote student responses in the "what I want to know" section. In this section, the teacher asked the students focus question in order to guide them into understanding what they want to answer about the question and what they need to know about it. For example he asked: "Do we need to know the ratio of Ali's height to his father's height in this problem?" Subsequently the teacher asked the students to solve the problem and wrote student answers on the "what I learned" section. In the following class the teacher handed out KWL worksheets to the students and gave them other problems. First, the students solved the problem individually according to the KWL strategy by using the worksheet. Then, the teacher drew the KWL chart on the board and the problem was solved by a student according to the KWL strategy (see Appendix A for sample student worksheet in KWL Group). According to Ogle (2005), the strategy is designed to be used by a teacher and a group of students working together, which then is easily transferred into a method for students' independent study. The teacher first leads the group through an oral discussion of each of the components and then turns the process over to students to individually write their own ideas and questions on a personal worksheet (p.64).

*Administering the post-tests*

Following the completion of experimental procedures the Math Achievement Test, the Metacognition Inventory, and Math Anxiety Scale were administered as post-tests to the study group and to the control group. The tests were given with 20 min rest intervals. Students were given 40 min for the Math Achievement Test while they were given 15 min each for the other two tests.

### Data analysis

Data collected to examine the differences between the study and control groups were tested and interpreted using the t-test for independent samples. According to Davison and Sharma (1988) if the observed variable Y meets the standard normality, several hypotheses tested with the t- or F- statistic are meaningful for ordinal variables (as cited in Davison and Sharma 1994). Single Sample Kolmogorov-Smirnov (K-S) Test was used in order to test whether the data collected from the scale were conforming to a specific distribution (uniform, normal or poison).

## Results and discussion

### Data analysis for hypothesis 1

The effects of KWL strategy on students' math achievement was investigated by comparing the post-test scores of students in the study group with the post-test scores of students in the control group on the Math Achievement Test (MAT). Single sample K-S test was used to determine which statistical technique should be used in order to point out whether there was a significant difference between the pre-test scores of the students in the study and control groups. The analysis results of the single sample K-S test showed that the pre-test scores of the study group (K-S (Z)=.656; $p>0.05$) and the pre-test scores of the control group (K-S (Z)=.874; $p>0.05$) were in a normal distribution. Therefore, it was agreed that the t-test for independent samples, which is a parametric test, should be used.

The analysis of pre-test scores for the MAT is presented in Table 1. This table shows that the study group's MAT pre-test mean score was 6.29 and the standard deviation was 3.54. The control group's MAT pre-test mean score was 6.19 and the standard deviation was 3.75. Table 1 indicates that while the mean scores of the study group was slightly higher than the mean scores of the control group, the difference was not statistically significant [$t_{(53)}=.098$, $p>.05$].

Hypothesis 1 tested in this experiment stated that there is a significant difference in the post-test score on the Math Achievement Test (MAT) between a group of sixth grade students who received KWL strategy instruction and group of sixth grade students who did not receive such instruction. The single sample K-S test was used in order to determine

**Table 1** Analysis of the pre-test and post-test scores for the MAT, MI, MAS

| Groups Compared | N | Mean | SD | df | t |
|---|---|---|---|---|---|
| Pre-test Scores MAT | | | | | |
| Treatment Group | 24 | 6.29 | 3.54 | 53 | .098 [a] |
| Control Group | 31 | 6.19 | 3.75 | | |
| Post-test Scores MAT | | | | | |
| Treatment Group | 24 | 16.58 | 2.69 | 53 | 6.845 [b] |
| Control Group | 31 | 8.77 | 5.06 | | |
| Pre-test Scores MI | | | | | |
| Treatment Group | 24 | 49.75 | 4.91 | 53 | −.228 [a] |
| Control Group | 31 | 50.31 | 4.27 | | |
| Post-test Scores MI | | | | | |
| Treatment Group | 24 | 62.64 | 5.78 | 53 | 4.415 [b] |
| Control Group | 31 | 52.86 | 9.57 | | |
| Pre-test Scores MAS | | | | | |
| Treatment Group | 24 | 24.20 | 4.72 | 53 | −.156 [a] |
| Control Group | 31 | 24.57 | 4.88 | | |
| Post-test Scores MAS | | | | | |
| Treatment Group | 24 | 22.03 | 4.11 | 53 | −.182 [a] |
| Control Group | 31 | 22.50 | 4.85 | | |

[a] $p>0.05$

[b] $p<0.05$

which statistical technique should be used to point of whether there was a significant difference between the students in the study and control groups regarding their final test scores. The analysis of the results of the single sample K-S test revealed that the study group's final test scores (K-S (Z)=1.140; $p>0.05$) and the control group's final test scores (K-S (Z)=1.009; $p>0.05$) were within a normal distribution. Therefore, the t-test for independent samples, which is a parametric test, was used.

The analysis of post-test scores for the MAT is presented in Table 1. This table shows that the study group's mean post-test score was 16.58 and the standard deviation was 2.69. The control group's mean post-test score was 8.77 and the standard deviation was 5.06.

Table 1 reveals that the difference between the post-test scores of the study group and the control group was statistically significant in favor of the study group [$t_{(53)}=6.845$, $p<.05$, $d=2.01$]. This indicates that the group which received instruction in KWL strategy made significantly greater scores on the MAT. Consequently, Hypothesis 1 was accepted.

The findings of this study are in parallel with Larmon (1995) who stated that the KWL strategy was efficient in choosing the right operation and in problem solving, and with El-Rahman (2011) who argued that writing activities including the KWL strategy increased achievement in mathematics classes.

Further, Cantrell et al. (2000) put forward that the reason for the efficiency of the KWL strategy in academic achievement was that the students wrote their responses before and after reading while using this strategy. According to these researchers, the fact the students were firstly writing what they knew triggers their previous knowledge and the fact that they were writing questions about what they want to know help them establish a purpose for reading. According to Headley and Dunston (2000) owing to the features of this strategy, students can reach the intended information easily from the pieces that constitute the subject. That is why KWL helps students make connections between isolated pieces of information. In this case it might have been effective in increasing the students' academic achievement.

Data analysis for hypothesis 2

The effects of KWL strategy on students' metacognition was investigated by comparing the post-test scores of students in the study group with the post-test scores of students in the control group on the Metacognition Inventory (MI). The single sample K-S test was used in order to determine which statistical technique should be used to point of whether there was a significant difference between the students in the study and control groups regarding their pre-test scores. The analysis of the results of the single sample K-S test revealed that the study group's pre-test test scores (K-S (Z)=.736; $p>0.05$) and the control group's pre-test test scores (K-S (Z)=.847; $p>0.05$) were within a normal distribution. Therefore, the t-test for independent samples, which is a parametric test, was used.

The analysis of pre-test scores for the MI is presented in Table 1. This table shows that the study group's MI pre-test mean score was 49.75 and the standard deviation was 4.91. The control group's MI pre-test mean score was 50.31 and the standard deviation was 4.27. Table 1 indicates that while the mean of the control group was slightly higher than the mean of the study group, the difference was not statistically significant [$t_{(53)}=-.228$, $p>.05$].

Hypothesis 2 tested in this experiment stated that there is a significant difference in the post-test score on the Metacognition Inventory (MI) between the group of sixth grade students who received KWL instruction and the group of sixth grade students who did not receive such instruction. The single sample K-S test was used in order to determine which statistical technique should be used to point of whether there was a significant difference between the students in the study and control groups regarding their final test scores. The analysis of the results of the single sample K-S test revealed that the study group's final test scores (K-S (Z)=.917; $p>0.05$) and the control group's final test scores (K-S (Z)=1.044; $p>0.05$) were within a normal distribution. Therefore, the t-test for independent samples, which is a parametric test, was used.

The analysis of post-test scores for the MI is presented in Table 1. This table shows that the study group's mean post-test score was 62.64 and the standard deviation was 5.78. The control group's mean post-test score was 52.86 and the standard deviation was 9.57. Table 1 reveals that the difference between the post-test scores of the study group and the control group was statistically significant in favor of the study group [$t_{(53)}=4.415$, $p<.05$, $d=1.27$]. This indicates that the group which received instruction in KWL strategy achieved significantly greater scores on the MI. Consequently, Hypothesis 2 was accepted.

These results are in parallel with the findings of a study conducted by Witherspoon in 1995 in which the author investigated the effects of metacognitive strategies including the KWL strategy on 6th graders' metacognitive awareness and reading comprehension. The results of the study showed that metacognitive strategies are effective in heightening metacognitive awareness. Similarly, Mok et al. (2006) have investigated the effects of metacognitive approaches on prospective teachers' self assessment and found that the KWL method has many positive features as a tool for self assessment and metacognition stating that the KWL method is designed to heighten the metacognition of the learner throughout the learning process.

In line with the results of the above mentioned studies, in the study that they conducted on 7th graders in the technology classroom by using the KWL strategy, Jared and Jared (1997) found that students took responsibility for their own learning. Furthermore, Cantrell predicts (as cited in Helm 2005) that by using the KWL concept in secondary school classrooms, students will become more engaged with the text, and practice metacognition while reading.

Data Analysis for hypothesis 3

The effects of the KWL strategy on students' math anxiety was investigated by comparing the post-test scores of the students in the study group with the post-test scores of the students in the control group on the Math Anxiety Scale. The single sample K-S test was used in order to determine which statistical technique should be used to point of whether there was a significant difference between the students in the study and control groups regarding their pre-test scores. The analysis of the results of the single sample K-S test revealed that the study group's pre-test test scores (K-S (Z)=.737; $p>0.05$) and the control group's pre-test test scores (K-S (Z)=.901; $p>0.05$) were within a normal distribution. Therefore, the t-test for independent samples, which is a parametric test, was used.

The analysis of pre-test scores for the MAS is presented in Table 1. This table shows that the study group's MAS pre-test mean score was 24.20 and the standard deviation was 4.72. The control group's MAS pre-test mean score was 24.57 and the standard deviation was 4.88. Table 1 indicates that while the mean scores of the control group was slightly higher than the mean scores of the study group, the difference was not statistically significant [$t_{(53)}=-.156$, $p>.05$].

Hypothesis 3 tested in the study stated that there is a significant difference in the posttest score on the Math Anxiety Scale (MAS) between the group of sixth grade students who received KWL strategy instruction and the group of sixth grade students who did not receive such instruction. The single sample K-S test was used in order to determine which statistical technique should be used to point of whether there was a significant difference between the students in the study and control groups regarding their final test scores. The analysis of the results of the single sample K-S test revealed that the study group's final test scores (K-S (Z) =1.050; $p>0.05$) and the control group's final test scores (K-S (Z)=1.004; $p>0.05$) were within a normal distribution. Therefore, the t-test for independent samples, which is a parametric test, was used.

The analysis of the post-test scores for the MAS is presented in Table 1. This table shows that the study group's mean post-test score was 22.03 and the standard deviation was 4.11. The control group's mean post-test score was 22.50 and the standard deviation was 4.85. Table 1 reveals that while the mean of the control group was slightly higher than the mean of the study group, the difference was not statistically significant [$t_{(53)}=-.182$, $p>.05$, $d=-.05$]. This indicated that there was no difference in math anxiety between the group which received instruction in KWL strategy and the group which did not. Consequently, Hypothesis 3 was rejected.

There are many factors affecting math anxiety (situational, personalistic, personal) (Baloğlu 2001), therefore the KWL strategy alone might not have been effective in decreasing math anxiety. But considering the fact that mathematics anxiety is rooted in primary school education. Studies related to anxiety should be started during the first years of education (Baloğlu 2001).

In her study, Bonnstetter (1999) aimed at investigating the factors that heighten mathematics anxiety. A math anxiety questionnaire was administered to 355 4-8th grade students and 18 students were interviewed in order to determine the factors that lead to math anxiety. The results of the study showed that certain methods of teaching curb mathematics anxiety. Hence, the uses of appropriate strategies to avoid factors that increase math anxiety were suggested. Moreover, some researchers have proposed that mathematics anxiety may stem from teaching methods that are more conventional, and rule bound (Ashcraft; Cote & Levine, Furner & Duffy; Hembree; Pintrich & Schunk; Singh, Granville, Dika; Tobias; Williams & Ivey; Zettle & Raines, as cited in Gresham 2007). Further, it has been found that field dependent students have higher mathematics anxiety than field independent students (Reece and Todd; as cited in Baloğlu 2001). Even though KWL strategy which has been used in this study is one that facilitates active and autonomous learning, it is significant that it has not been effective in decreasing mathematics anxiety. This could perhaps stem from the fact that the time allocated for the study was not sufficient.

## Conclusions and implications

The results of the study show that the application of the KWL strategy in the 6th grade mathematics classroom is effective in increasing students' math achievement. The large effect size *(d)* measured for the post- Math Achievement Test (MAT) also indicates the practical significance of the result related to achievement. Based on these results, it can be suggested that the KWL strategy can be used in the 6th grade mathematics classroom in increasing their math achievement. According to Jared and Jared (1997) the constituents of this strategy help facilitate students to recall prior knowledge, develop self-questioning strategies, read for the purpose of answering questions, and promote opportunities for further research. The KWL strategy provides a means by which students learn and simultaneously become responsible for their own learning. Draper (2002), too, states that this strategy is an instrument that enables having more indebpendent learners. Based on all these reasons the KWL strategy might have been effective in academic achievement.

There are studies, though limited, that show that the KWL strategy is effective in academic achievement in math classes. Larmon tested (1995) the effect of KWL, Polya's Problem Solving Plan, and Directed Inquiry Activity on third graders' ability to solve mathematical word problems. At the end of the study, the KWL group outperformed the other groups in both choosing the correct operation and in solving the problem correctly. El-Rahman (2011) also found out that writing activities including the KWL strategy increased achievement in math classes.

Studies conducted on different classes, too, show that the KWL strategy is effective in academic achievement. Cantrell et al. (2000) state that the KWL comprehension strategy increases academic achievement in 7th graders' social sciences classes. Further, Piper (1992) examined the effects of metacognitive strategies including the KWL strategy on reading comprehension in the social sciences classroom and the results of the study showed a rise in students' social sciences grades and development in their reading comprehension skills.

Reichel (1994), moreover, found that the KWL strategy has a positive effect on student performance in the science classroom while Mclaughlin (1994) emphasized the positive effects of the KWL strategy on student assessment and indicated that that KWL is an encouraging model which facilitates learning science, and develops students' organizational skills. Akyüz (2004) too argues that this strategy increases the students' achievement in his work on the effect of textbook style and the KWL strategy on the students' achievement and attitude regarding the subject of heat and temperature. In their study in which they applied the KWL strategy in 7th grade technology course, Jared and Jared (1997) also stated that this strategy was much better than the traditional method of instruction and that while applying this strategy, students took responsibility of their own learning.

There are also studies that demonstrate that the KWL strategy is effective in reading comprehension. Al Khateeb and Idrees (2010) have found that the KWL strategy has an effect on increasing 10th graders' reading comprehension levels. Al-Shaye (2002) investigated the effectiveness of metacognitive strategies on reading comprehension and comprehension strategies of 11th grade male students in Kuwaiti high schools on the subject of Arabic language. This study concentrated on two metacognitive strategies (the KWL Plus and the SQ3R strategies) and compared them with the traditional approach of teaching reading in Kuwaiti high schools. The findings of this study indicated that the metacognitive strategies had greater positive effects on students' reading comprehension and comprehension strategies than the traditional approach. Hall (1994) investigated the effects that Ogle's Know, Want to Know, Learn, Plus strategy (KWL, Plus) and Stauffer's Directed Reading-Thinking Activity (DR-TA) had on students' recall of expository text when compared to traditional instruction and the effects of using cooperative learning with KWL, Plus, DR-TA, and traditional instruction. The results revealed that the differences among the strategy means were statistically significant. KWL, Plus was the most effective for students reading passages at or above their level of reading ability.

In addition, the results of the study show that the application of the KWL strategy in the 6th grade mathematics classroom is effective in increasing students' metacognitive skills. The large effect size *(d*) measured for the post- Metacognition Inventory (MI) also indicates the practical significance of the result related to metacognition. Based on these results, it can be suggested that the KWL strategy can be used in the 6th grade mathematics classroom in order to increase students' metacognitive skills. Studies conducted by Witherspoon (1995) and Mok et al. (2006), who found out that the KWL strategy was effective in metacognition, support the results of this study. According to Ogle (2005, p.71) "having each student involved in writing her own ideas before, during, and after reading is central to the KWL strategy. The writing helps students continually monitor their own thinking and learning on the worksheet". Further, the KWL strategy helps students to assess their own learning (Glazer & Ogle; as cited in Helm 2005). KWL places a focus on the student being a strategic learner whereby the students use the KWL process to think critically, read, and learn on their own (Brozo and Simpson 1991, 83). This strategy promotes active learning through reading, writing, discussing and/or problem solving (Fritz 2002). The KWL strategy serves several purposes: Sets a purpose for reading, helps students to monitor their comprehension, allows students to assess their comprehension of the text (Conner 2006). That is why the KWL strategy used in this study might have been effective in heightening metacognition.

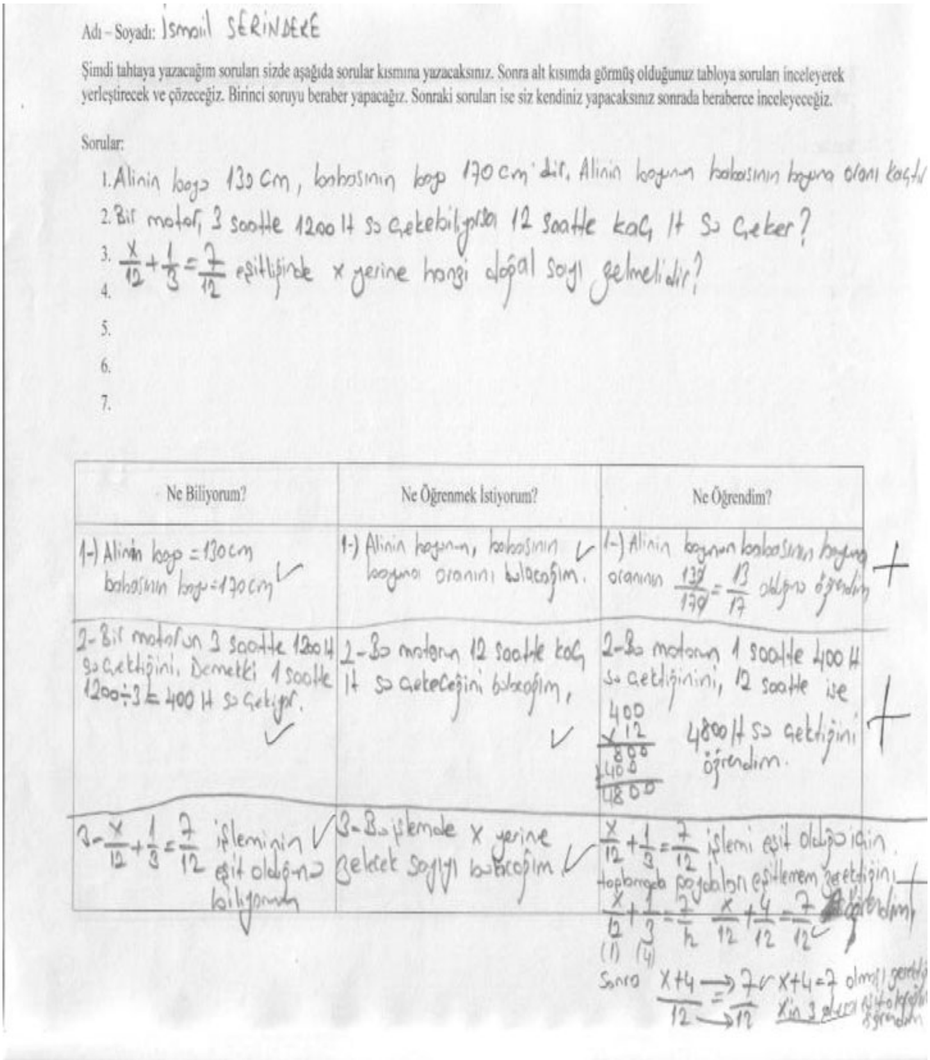
On the other hand, the results of the study show that the KWL strategy is not more effective than the traditional teaching methods in reducing the level of math anxiety. KWL has a weak effect size on math anxiety. In a similar study, Creighton-Lacroix (2000) found that "metacognitive strategy instruction was not successful in alleviating test anxiety." The reason the author set for its reason is "task difficulty and time". According to the author, metacognitive strategy instruction is a long process requiring time for practice, automaticity, and success. This study, however, was limited to 8 weeks and 32 class hours. According to this, in order to reduce math anxiety long term studies can be undertaken regarding the KWL strategy. Besides, according to Nathan (2000) tasks about metacognition requiring higher order executive process might have a negative effect on students' math anxiety since these tasks might be difficult and complicated for the students. Therefore, it can be said that the KWL, as a metacognitive strategy, may not have a positive effect in reducing the level of anxiety.

Based on these results; we can recommend that in order to increase academic achievement and metacognitive skills, KWL strategy may be used in 6th graders' mathematics classes and the teachers and teacher candidates can be informed about these strategies.

This study is limited to the subjects of fractions, decimal fractions, and ratio-proportion and 6th grade students regardless of their levels of learning in mathematics classes. Therefore, the findings of this study can be generalized to this grade level and to these subjects. Further studies which will focus on different subjects, different student levels and different variables (attidue, self-efficacy, etc.) may provide researchers with an opportunity to test the KWL strategy from these perspectives and help us add systematic information to the theoretical basis of this strategy. Also, this study is limited to the small sample size. It can be recommended that studies need to be conducted using a large sample in the future.

## Appendıx A

Sample Student Worksheet in KWL Group



Adı - Soyadı: İsmail SERİNDERE

Şimdi tahtaya yazacağım soruları sizde aşağıda sorular kısmına yazacaksınız. Sonra alt kısımda görmüş olduğunuz tabloya soruları inceleyerek yerleştirecek ve çözeceğiz. Birinci soruyu beraber yapacağız. Sonraki soruları ise siz kendiniz yapacaksınız sonrada beraberce inceleyeceğiz.

Sorular:

1. Alinin boyu 130 cm, babasının boyu 170 cm'dir. Alinin boyunun babasının boyuna oranı kaçtır
2. Bir motor, 3 saatte 1200 lt su çekebiliyorsa 12 saatte kaç lt su çeker?
3. $\frac{x}{12}+\frac{1}{3}=\frac{7}{12}$ eşitliğinde x yerine hangi doğal sayı gelmelidir?
4.
5.
6.
7.

| Ne Biliyorum? | Ne Öğrenmek İstiyorum? | Ne Öğrendim? |
|---|---|---|
| 1-) Alinin boyu = 130 cm babasının boyu = 170 cm ✓ | 1-) Alinin boyunun, babasının boyuna oranını bulacağım. ✓ | 1-) Alinin boyunun babasının boyuna oranının $\frac{130}{170}=\frac{13}{17}$ olduğunu öğrendim +|
| 2- Bir motorun 3 saatte 1200 lt su çektiğini. Demekki 1 saatte 1200÷3 = 400 lt su çekiyor. ✓ | 2- Bu motorun 12 saatte kaç lt su çekeceğini bulacağım. ✓ | 2- Bu motorun 1 saatte 400 lt su çektiğini, 12 saatte ise 400 × 12 = 800 + 400 = 4800 4800 lt su çektiğini öğrendim. + |
| 3- $\frac{x}{12}+\frac{1}{3}=\frac{7}{12}$ işleminin eşit olduğunu biliyorum ✓ | 3- Bu işlemde x yerine gelecek sayıyı bulacağım ✓ | $\frac{x}{12}+\frac{1}{3}=\frac{7}{12}$ işlemi eşit olduğu için toplarken paydaları eşitlemem gerektiğini öğrendim $\frac{x}{12}+\frac{1}{3}=\frac{7}{12}$ $\frac{x}{12}+\frac{4}{12}=\frac{7}{12}$ Sonra $\frac{x+4}{12}\to\frac{7}{12}$ x+4=7 olması gerektiğini x'in 3 olması gerektiğini öğrendim + |

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