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The instructional effectiveness of a web-based version of the "cognitive training for children"

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The instructional effectiveness of a web-based version of the "cognitive training for children"

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Signatures have been redacted for privacy

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ABSTRACT

The Web-based version of the "Cognitive Training for Children" program (WCTC) was designed to help improve 4th grade students' problem-solving abilities in fractions through teaching inductive reasoning skills, especially for those who have difficulty in acquiring skills for fractions through regular classroom instruction. This study evaluates the instructional effectiveness of WCTC program. It also examines the comparative effects of the WCTC program on students who are identified as high and low performers in terms of their fractions performance on the fractions pretest. Participants were two 4th grade classes: one class with 20 students was randomly assigned to the training group to receive training with the WCTC program and another class with 19 students was assigned to the control group. A pretest-posttest design was employed in this study. A $2 \times 2 \times 2$ RM-ANOVA was performed. Significant effects were observed for test, the test by performance level interaction, and the test by group by performance level interaction. The main effects of group and the interaction effects of test by group were not significant. These results indicates that the WCTC program is effective in improving 4th grade students who are identified as low performers with fractions, although it is not effective for the whole class. The information gained in this study provides empirical evidence about the instructional effectiveness of the WCTC program. It also adds to the body of knowledge regarding the central role of inductive reasoning in problem-solving.

CHAPTER 1. INTRODUCTION

1.1 The Cognitive Training for Children Program

Since the beginning of the late 1980s, various programs to enhance children's cognitive abilities have been developed and published in Europe, especially in Germany. The *Cognitive Training for Children Program*, which was designed to teach young children how to use higher-order thinking skills as tools in the development of inductive reasoning and academic problem-solving abilities, was introduced originally in Germany by Klauer (1989a). It subsequently has been translated and adapted for use in the United States (Klauer & Phye, 1994), and the Netherlands (Klauer, Resing, & Slenders, 1995).

The overall goal of the Cognitive Training for Children (CTC) Program is the development of competency in inductive reasoning and problem-solving. The theoretical rationale of the program is an integration of aptitude theory and information processing theory. Current aptitude theory views the aptitudes of inductive reasoning and problem-solving as cumulative learning potentials that develop through practice. Furthermore, these aptitudes are not merely correlates of learning, but are propaedeutic to (i.e., necessary as preparation for) higher-order learning (Klauer & Phye, 1994). From an information processing perspective, structured thinking processes provide the basis for construction and development of these aptitudes. Successful strategic transfer of problem-solving knowledge acquired during learning or training has been shown with formally defined procedures and strategies (Phye, 1992). Therefore, teaching young children how to acquire and practice the basic thinking processes that define inductive reasoning and how to transfer these basic inductive reasoning procedures across problem domains are the main ingredients of the CTC program. Both cognitive and meta-cognitive strategies are taught directly to children to promote the development of inductive reasoning and problem-solving abilities.

The CTC program can be used as a supplement in the classroom to help students who have difficulty in problem-solving or as an assessment tool to measure students' inductive reasoning skills. The success of the CTC program for both regular classroom students and learning disabled students as young as five years of age has been validated by a number of studies (Hager & Hasselhorn, 1998; Klauer & Phye, 1994; Phye & Sanders, 1999b).

1.2 A Web-based Version of the Cognitive Training for Children

During the past decade, the rapid development of computer and Internet technology has greatly affected the form of instruction and learning. Traditional classroom-based instruction has been challenged by computer aided instruction (CAI) to some extent. In particular, the World Wide Web is being touted as a viable means of delivering instruction because of the amount and interactive nature of its information that is accessible at a low cost and its ability to integrate multimedia such as graphics, sound, and animation (Verrest, 2000). Many professors and teachers have supplemented their courses with Web-based technologies, ranging from putting course materials and assignments on the Web to virtual simulations and assessment. There are also some courses being delivered online without face-to-face interaction. Numerous studies have shown that CAI, including Web-based instruction, is effective for enhancing students' learning, including higher-order thinking skills such as critical thinking and reasoning (Renshaw & Taylor, 1999; Roschelle, Pea, Hoadley, Douglas, & Means, 2000; Schacter, 1998; Wenglinsky, 1998).

A Web-based version of the Cognitive Training for Children (WCTC) Program was developed by Verrest in 2000. This program, designed for 4^{th} grade students, is based on: 1) document analysis of human factors knowledge and design guidelines; 2) information provided by 4^{th} grade teachers regarding the prospective users of the WCTC program and the context in which the program will be used; and 3) feedback provided by 4^{th} grade students who tested the prototypes of the WCTC program. The overall goal of the WCTC program is to teach 4^{th} grade students who have difficulty in acquiring skills for fractions through regular classroom instruction how to solve fractions problems by using inductive reasoning skills. The development of the WCTC program is based on theories of inductive reasoning and problem-solving transfer, as well as principles of usability. It has been labeled as a usable application after an examination of usability issues such as learnability, efficiency, errors, and satisfaction (Verrest, 2000).

1.3 Statement of the Problem

The WCTC program has been examined in terms of its technical usability. However, its instructional effectiveness is unclear. This study investigated the instructional function of the WCTC program. More specifically, it attempted to answer the question: do 4^{th} grade students who receive training with the WCTC program have significantly greater gains in fractions performance than untrained students?

In addition, this study investigated the comparative effects of the WCTC program on students who are identified as high and low performers. Researchers have investigated the effectiveness of the CTC program on students at different intelligence levels, and found that mentally retarded and gifted students benefited from the CTC program as well as normal students (Hager & Hasselhorn, 1998; Klauer & Phye, 1994). However, no study has been conducted to compare the effects of the CTC program for normal students at different performance levels such as high, medium, and low. Since the WCTC program was developed as a supplement to help students who have difficulty with fractions, this study attempted to determine whether students who are identified as low performers benefit significantly more than high performers from the WCTC program.

1.4 Purpose of the Study

The purpose of this study is to evaluate the effectiveness of the WCTC program in improving 4th grade students' performance in fractions. In addition, this study attempts to investigate the comparative effects of the WCTC program on students who are identified as high and low performers.

It is expected that the information gained in this study will provide empirical evidence about the instructional effectiveness of the WCTC program, which may serve as the basis for further modification. It is also hoped that this study will add to the body of knowledge regarding the central role of inductive reasoning in problem-solving.

1.5 Human Subjects Release

The Iowa State University Committee on the Use of Human Subjects in Research reviewed this project in an effort to ensure that the rights and welfare of the human subjects participating are adequately protected. They concluded that no physical or emotional risks were present, that confidentiality was assured, that informed consent was obtained by appropriate procedures, and that potential benefits and expected value of knowledge sought were acceptable.

CHAPTER 2. LITERATURE REVIEW

This chapter will be organized around four points: (a) the theoretical basis of the CTC program and the WCTC program; (b) the construction of the CTC program; (c) the overview of research activities involving the validation of the CTC program; and (d) the overview of the WCTC program.

2.1 Theoretical Basis for the Training Programs

The CTC program was designed to teach young children how to use inductive reasoning as a tool to solve academic problems across various problem contexts. The WCTC program emphasizes on 4^{th} grade fractions problems such as simple fractions addition and subtraction, fractions equivalence, and fractions simplification. However, these two training programs have a similar theoretical basis, which is "current cognitive, psychological research that is concerned with the clarification of cognitive components involved in information processing, especially those involved in the solution of intellectually demanding problems" (Klauer & Phye, 1994, p.31). Consequently, they are based on: 1) an empirical theory of inductive reasoning and problem-solving; and 2) theories of problem-solving transfer.

2.1.1 Inductive Reasoning

The training programs draw on both aptitude theory and a cognitive information processing approach to inductive reasoning and problem-solving. Current aptitude theory (Snow, 1992) views aptitudes as cumulative learning potentials that develop through practice. Aptitudes such as generalization, discrimination, and a monitoring algorithm checking for similarities/differences are propaedeutic to (i.e., necessary as preparation for) higher-order thinking skills and problem-solving development. From an information processing perspective, which emphasizes the mental processes of cognitive activities, inductive reasoning can be viewed as specific strategies and procedures to be acquired and remembered by the learner, and then retrieved later to facilitate the solving of a similar problem. However, common to these perspectives is the emphasis on inductive reasoning as a basic, or central, process to higher-order thinking and problem-solving performance.

Importance of Inductive Reasoning

Induction is the process of detecting regularities, rules, or generalizations and, conversely, irregularities. "Regularity plays an important role in thought because regularities and uniformities provide the basis for concepts and categories that serve as basic knowledge for abstract thinking and reasoning." (Klauer & Phye, 1994, p.37) Therefore, inductive reasoning has been identified by a number of researchers as a basic process in problem-solving, although it alone may not be sufficient for problem-solving.

There is agreement among researchers that a close relationship exists between inductive reasoning and intelligence. In the factor-analytical tradition, Spearman (1923) was convinced that inductive reasoning plays a major role with respect to his general factor of intelligence. Further studies by Snow, Kyllonen, and Marshalek (1984), and Undheim and Gustafsson (1987) have demonstrated that the concept of general intelligence is significantly determined by fluid intelligence, g_f, which in turn is determined by the process of inductive reasoning.

Another evidence for the central role of inductive reasoning in intelligence is that almost all intelligence tests contain tasks or subtests such as analogies, classification, series completion, and matrices. These four problem formats have been identified by researchers as requiring inductive reasoning (Goldman & Pellegrino, 1984; Sternberg & Gardener, 1983). While intelligence tests do contain many items that are not concerned with inductive reasoning, it is hard to find one that does not contain some tasks of inductive reasoning. Moreover, there are some tests, such as Miller Analogies, Raven Matrices, and Cattell's Culture Fair Test, that consist solely of inductive reasoning.

Since the 1970s, constructivism influenced inductive reasoning research from an information processing perspective (Glaser & Pellegrino, 1982; Goldman & Pellegrino, 1984; Sternberg, 1977, 1986a, b). A number of researches were engaged in reconstructing the mental processes that are going on when subjects are solving inductive problems. The process analysis provides the basis for the development of inductive reasoning definition followed by the training programs.

A Definitional Model for Inductive Reasoning

The following definitional model (Klauer & Phye, 1994) for inductive reasoning, as presented in Figure 1, was used to generate the practice materials used for the training programs. The definition defines the operations as well as the content of inductive reasoning. It precisely specifies the thinking processes that distinguish between inductive reasoning and other types of reasoning. "As a result, the definition has the status of a theory that specifies those cognitive processes that constitute inductive reasoning" (Klauer & Phye, 1994 p.40). More specifically, it is a prescriptive theory of inductive reasoning as it specifies the processes considered to be sufficient to discover a generalization or to refute an overgeneralization.

Inductive reasoning consists of detecting regularities and irregularities by finding out

$$\begin{array}{ccc} A & & B \\ \left\{ \begin{array}{l} a_1 \text{ similarity} \\ a_2 \text{ dissimilarity} \\ a_3 \text{ similarity \&} \\ \quad \text{dissimilarity} \end{array} \right\} & \text{of} & \left\{ \begin{array}{l} b_1 \text{ attributes} \\ b_2 \text{ relations} \end{array} \right\} \end{array}$$

$$\begin{array}{c} C \\ \text{with} \left\{ \begin{array}{l} c_1 \text{ verbal} \\ c_2 \text{ pictorial} \\ c_3 \text{ geometric-figural} \\ c_4 \text{ numerical} \\ c_5 \text{ other} \end{array} \right\} \text{materials} \end{array}$$

Figure 1. Definitional model for inductive reasoning

The definitional model of inductive reasoning is given in the form of an incomplete mapping sentence. It contains three facets A, B, and C with 3, 2, and 5 distinct elements. Hence, 3*2*5=30 different kinds of inductive reasoning problems can be constructed. According to Figure 1, inductive reasoning is a process of detecting regularities and irregularities by finding out (A) similarities or/and dissimilarities of (B) attributes or relations with academic content that are (C) verbal, pictures, figures, numbers, etc.

Facet A is designated as the comparison facet. It determines whether one has to look for similarities or differences, or both similarities and differences, when comparing objects. Regularities are revealed only when one pays close attention to similarities and differences. Facet B identifies the elements to be compared. It specifies that comparisons are not made globally based on objects as a whole, but rather specifically on attributes or relations. In terms of predicate logic, attributes are one-place predicates and relations are two-or-more place predicates. A predicate is a verb phrase template that describes an attribute of objects, or a relationship among objects. For example, the sentences that "the car is blue," "the sky is blue," and "the cover of this book is blue" come from the template "is blue" by placing an appropriate noun phrase in front of it. The phrase "is blue" is a one-place predicate and it describes the attribute of being blue. Similarly, the sentences that "1/2 is two times 1/4" and "1/5 is two times 1/10" contain a two-place predicate "x is two times y" which describes a relationship between x and y. Since attributes and relations exhaust all the possibilities of talking about objects, Facet B can be designated as the predicate facet. Facet C indicates five classes of materials that can be used to develop a problem. More accurately, there are four classes (verbal, pictorial, geometric-figural, and numerical) plus one non-specific class (other). These five classes are employed here because they occur frequently in tests of cognitive aptitudes. However, facet C can be constructed in several different ways. For instance, facet C can be conceptualized according to school subjects such as mathematics, geography, language, etc. Facet C is a material facet.

Facet A and B are interpreted as central facets of inductive reasoning. They display six basic types of inductive reasoning tasks that correspond to the six processes that constitute inductive reasoning. The names of the six basic inductive processes and the interrelationships among them are depicted in Figure 2. The left branch of the "family tree" in Figure 2 contains the three inductive tasks that require the processing of surface information about the attributes: Generalization (GE), Discrimination (DI), and Cross Classification (CC). GE is the process of recognizing the similarities of attributes of objects, DI is the process of recognizing the differences of attributes among objects, and CC requires identification of both similarities and differences in attributes. The right branch of the "family tree" refers to the three inductive reasoning processes that are characterized by making comparisons with respect to the relationships among objects (structural information): Recognizing Relationships (RR), Discriminating Relationships (DR), and System Construction (SC). RR is the process of recognizing the similarity of relationships, DR is the identification of differences in relationships, and SC requires identification of both similarities and differences in relationships. Figure 2 also provides a representation of the superordinate-subordinate relationship. For example, both generation and discrimination are necessary to be successful with a cross classification task. The same logic exists between recognizing/differentiating relationships and system construction.

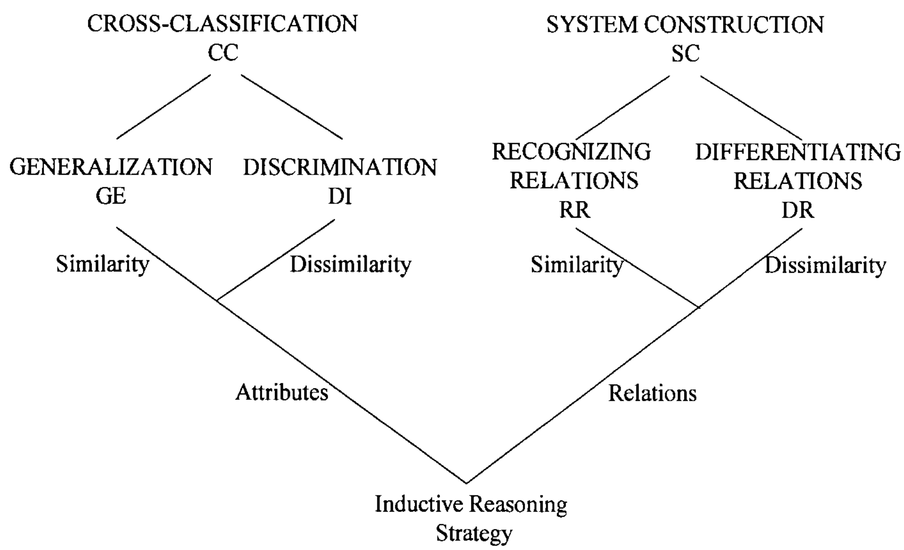

Figure 2. The genealogy of tasks in inductive reasoning

In the previous paragraph, the cognitive processes of inductive reasoning are defined by the thinking operations that are employed during reasoning. For instance, generalization is defined operationally as the process of recognizing similarities with respect to the attributes of objects. A summary of the six reasoning processes and the respective cognitive operations involved with inductive reasoning is presented in Table 1, which provides the basis for developing the training tasks.

Since all inductive reasoning tasks can be attacked by first considering the similarity and difference of either attributes or relationships, teaching young children to use the meta-cognitive strategy of making analytical and systematic comparisons becomes the heart of the training procedure. Two strategies have been developed sharing the comparison process (Klauer, 1989, 1996; Klauer & Phye, 1994). The *analytical strategy* is a paired-comparison procedure that systematically compares single objects with respect to common attributes, and pairs of objects with respect to common relationships. However, children rarely will proceed according to the analytical strategy because it assumes they recognize all attributes or relationships when the problem is presented. Most children first will try the *global heuristic strategy*, which starts with formulating reasonable hypotheses about the correct solution through a quick, global inspection of the objects. These hypotheses can be tested by scrutinizing particular attributes of, or relationships among, the relevant objects. Only if the global heuristic strategy is not successful are children advised to employ the more laborious, but also more successful, analytical strategy.

Table 1. Inductive thinking processes with problem formats

Processes	Facet Identification	Problem Formats	Cognitive Operation Required
Generalization (GE)	a1b1	class formation class expansion finding common attributes	similarity of attributes
Discrimination (DI)	a2b1	identifying irregularities	discrimination of attributes (concept differentiation)
Cross Classification (CC)	a3b1	4-fold scheme 6-fold scheme 9-fold scheme	similarity & difference in attributes
Recognizing Relationships (RR)	a1b2	series completion ordered series simple analogy	similarity of relationships
Differentiating Relationships (DR)	a2b2	disturbed series	differences in relationships
System Construction (SC)	a3b2	Matrices	similarity & dissimilarities in relationships

2.1.2 Problem-Solving Transfer

The CTC and WCTC programs are designed to help students use inductive reasoning skills acquired during training as a tool to solve similar but different academic problems. Therefore, successful problem-solving transfer from training to delayed tasks is a necessity for the success of the training programs. According to Holyoak and Spellman (1993), "Essentially by definition, transfer is based on the perception that prior knowledge is relevant to the current context" (p. 297). More specifically, problem-solving transfer refers to the abilities to apply what one has learned to new tasks that have similar characteristics.

Two Perspectives of Problem-Solving Transfer

From a behavioral perspective, problem-solving transfer depends on the similarity of surface elements or characteristics shared by training/learning and transfer problems (Cormier & Hagman, 1987; Klauer & Phye, 1994; Yamnill & Mclean, 2001). The descriptors of positive transfer, negative transfer, and zero transfer (Phye, 1992) are commonly accepted terms for describing transfer. For instance, there should be high positive transfer if the tasks in both training and transfer have similar characteristics (e.g., stimuli and responses), and, conversely, there should be negative transfer if the tasks in the two settings have the same stimuli but different responses.

The approach followed in the development of the training programs is the information processing perspective. In contrast to the behavioral perspective, which attempts to explain transfer solely in terms of surface characteristics, information processing theory suggests that cognitive processes must be taken into consideration. This is a two-factor theory of transfer in which both surface characteristics of problem-solving tasks and the cognitive activities of the problem solver are necessary for successful transfer (Klauer & Phye, 1994).

Studies (see Segal, Chipman, & Glaser, 1985; Sternberg, 1985; Weinert & Kluwe, 1984, Klauer & Phye, 1994) regarding the common cognitive activities shared by training and transfer tasks have shown that there is a distinction between cognitive strategies and meta-cognitive strategies. Cognitive strategies refer to the procedural and strategic strategies used in problem solution. They are strictly domain specific and constitute the primary basis for transfer within the domain that is well defined. Meta-cognition refers to learners' automatic awareness of their own knowledge and their ability to understand, control, and manipulate their own cognitive processes.

Academic Knowledge

Because remembering of prior academic knowledge is the source of problem-solving transfer, the nature of academic knowledge must be addressed. The types of knowledge and terminology have been discussed broadly in the literature (Alexander, Scallert, & Hare, 1991). From a functional perspective, a distinction has been made among various types of knowledge in terms of knowing what, knowing how, and knowing when and how (Brown, 1978). Mayer (1987) has adapted this perspective and translated it into declarative knowledge, procedural knowledge, and strategic knowledge (Phye, 1992).

In Mayer's model of academic knowledge, declarative knowledge involves knowledge of facts, concepts, vocabulary, and so forth. Knowing how to use declarative knowledge is called procedural knowledge. That is, procedural knowledge involves knowledge of the steps, the process, and the procedures used on a specific situation. Strategic knowledge refers to skills in knowing when and how to use declarative and procedural knowledge to construct a learning outcome. More specifically, strategic knowledge enables learners to choose at appropriate times the appropriate knowledge to bear on learning, remembering, and problem solving. It is self-directed and volitional skills (Phye, 1992).

Instead of viewing descriptions of steps and processes as procedural knowledge, John Anderson (1983, 1995) of Carnegie-Mellon University has a knowing-is-in-the-doing view of procedural knowledge. Anderson refers to descriptions of steps and processes as declarative knowledge. Starting out as declarative knowledge, procedural knowledge can only be acquired by employing declarative knowledge in the context of a problem solving activity. "Procedural knowledge can not be learned by simply being told" (Anderson, 1983).

Although different opinions exist in this area, researchers agree that procedural and strategic knowledge represents meaningful learning and the ability to demonstrate these two categories reflects a true comprehension or understanding of academic content.

Strategic Transfer

Strategic transfer is an operational definition of strategic knowledge (Phye, 1992). From an information processing perspective, strategic transfer is the product of mindful mental activities and can be viewed as a tool for successful problem-solving (Phye, 1992). Within the context of academic problem-solving, strategic transfer can be viewed as the ability of spontaneous access and retrieval of prior knowledge in the construction of solutions for complex tasks.

Strategic transfer is volitional and spontaneous. To attack this nature, no reminders or hints of prior instruction or acquisition should be provided to the problem solver when the problem is presented. This approach requires the problem solver spontaneously to initiate and carry out the strategies and procedures necessary for solution construction. In this case, the problem solver is responsible for all the problem-solving processes identified by Mayer: problem identification, problem representation, solution selection, and solution execution (Phye, 1992). In contrast, the transfer would be nonstrategic if instructions at transfer encourage a problem solver to remember what had been taught previously. Phye (1992) argues that, in this case, the problem identification and problem representation stages of the problem-solving processes have been provided to the problem solver.

Strategic transfer defines a level of competency that is demonstrated not only by the volitional nature, but also by durability. That is, the spontaneous transfer must be memory-based to demonstrate durability of strategic transfer, which, in a training-for-transfer program, can be assessed by using a delayed problem-solving task that provides new problems from within the same problem-solving domain.

Memory-Based Processing

From an information processing perspective, the distinction between immediate transfer and delayed transfer is significant (Phye, 1989, 1992, 1997a). The same distinction within the context of transfer has been made by Salomon and Perkins (1989), using the terms "forward reaching" (immediate) transfer and "backward reaching" (delayed) transfer. This distinction is necessary to address questions about the durability of strategic transfer (Phye, 1991).

Immediate transfer requires on-line processing within a practice or learning episode. In the learning episode, where the problem-solving context is provided, retrieval from working memory of prior successful examples and corrective feedback for unsuccessful examples provides the basis for transfer within the learning situation. Delayed transfer refers to judgments that follow the practice or learning episode and are based on knowledge retrieved from long-term memory. In this case, where the problem-solving context must be constructed, memory-based processing is required.

Using a procedural analysis approach, Massaro and Cowan (1993) state that memory-based processing consists of acquisition, retention, and retrieval stages. In a training-for-transfer paradigm, memory acquisition occurs in the training phase. Long-term memory retention, which documents the availability of acquired procedures and strategies, can be demonstrated in a direct memory retention task presented several days after the training. Retrieval is critical for successful problem-solving in the delayed problem-solving task because it involves the access and comparison of knowledge acquired in training. Access and comparison stages constitute memory search that is critical for the problem identification phase of the problem-solving process. "Successful memory search eliminates the inert knowledge problem characterized as available knowledge that is not used during problem-solving" (Phye, 1994, p.288).

For prior knowledge to be accessed and used as a tool, that knowledge first must be stored and available in long-term memory. However, availability does not guarantee the occurrence of spontaneous access, although it itself is a necessary condition for successful strategic transfer (Phye, 1992, 1994; Tulving, 1983). Phye (1994) argues that memory retrieval during problem-solving is not automatic and is based on practice and study. The training-for-transfer model offered in the CTC program and WCTC program provides a context within which young students practice memory acquisition, memory retention, and memory retrieval of problem-solving procedures and strategies.

Transfer-Appropriate Processing and Procedures Models

Tulving (1983) describes the relationship between learning (acquisition) and retrieval by his encoding specificity principle. The encoding specificity principle says that the chances of retrieving information are best if the situation in which retrieval is attempted is similar to the situation in which learning took place. The mental processing of these two situations is an important part. Keeping the processing the same increases retrieval.

Based on Tulving's encoding specificity principle, two models were developed to promote strategic transfer: transfer-appropriate processing model and transfer-appropriate procedures model (Phye, 1992). Both models fit well within an information processing perspective by emphasizing the compatibility of content and processes between acquisition and transfer tasks. The distinction between the two models is that the transfer-appropriate processing model emphasizes the encoding at acquisition, while the transfer-appropriate procedures model emphasizes the processing (e.g., schema construction) at retrieval. From an integrated view of transfer-appropriate processing and procedures, Phye (1992) states that strategic transfer is the result of mindful encoding during acquisition and self-directed schema-abstraction at retrieval.

An integration of the transfer-appropriate processing and procedures models is proposed through the development of a training-for-transfer paradigm (Phye, 1990). The CTC and WCTC programs are examples of this paradigm. By using the training-for-transfer paradigm, one can deal with processing issues at both acquisition and retrieval. Also, one can estimate prior problem-solving knowledge by performance on the first practice trial, assess the development of problem-solving ability across practice/study trials, and assess strategic transfer by employing a delayed problem-solving task (Phye, 1997b).

Effect Size of Transfer

To predict the effect size of transfer, Osgood (Klauer & Phye, 1994) developed the transfer surface model based on the behavioral perspective that transfer depends on the similarity of surface characteristics or elements (Cormier & Hagman, 1987; Klauer & Phye, 1994; Yamnill & Mclean, 2001). The transfer surface model takes only the surface characteristic similarities into consideration and is viewed as a single-dimension model. It views transfer effects as a linear function of the similarity of surface characteristics. That is, the transfer decreases linearly as the similar elements or characteristics shared by training and transfer tasks decrease. Taking the undimensional assumption, it would be expected that when the similar surface elements shared by training and transfer tasks become zero, the transfer effect is also zero.

In 1989, Klauer (Klauer & Phye, 1994) proposed a two-dimensional model based on current information processing theory of transfer that argues for a two-dimensional perspective by considering both "surface" and "deep" structural elements (Vosniadou & Ortony, 1989). This model considers the possibility that transfer is multidimensional and may occur in several directions. The multidimensional spread of transfer effects is depicted by circles in Figure 3. However, if a radius placed across a set of concentric circles, the transfer effect does decrease as the distance from the center increases.

The model in Figure 3 also can be viewed as a paradigmatic transfer model. Within the inductive reasoning context, a formal reasoning structure that is content-independent and applicable in various problem-solving situations is a paradigm. Paradigmatic transfer occurs when the learner truly understands a formal reasoning process (paradigm) and successfully

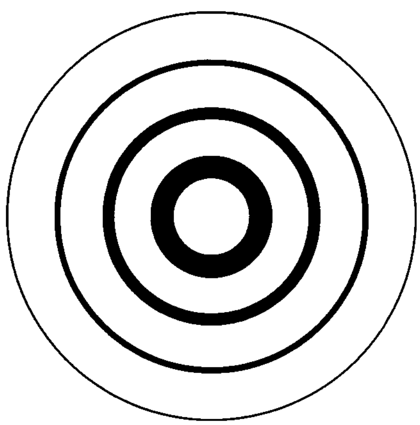

Figure 3. The spread of paradigmatic transfer

uses it as a tool in different situations. In general, inductive reasoning can be explained in terms of six closely related paradigms: generalization, discrimination, cross classification, recognizing relationship, differentiating relationships, and system construction.

As we mentioned previously, such transfer of formal reasoning structures does not occur spontaneously, and the practice of paradigmatic transfer is necessary for the learner to access the appropriate paradigms in long-term memory. The CTC program and WCTC program can be viewed as paradigmatic training because they attempt to optimize the transfer by providing a training and practice context. Through training and practice, a broader application of reasoning strategies is achieved.

2.2 Construction of the CTC Program

The CTC program consists of 120 problems, 20 for each of the 6 types of inductive reasoning procedures (GE, DI, CC, RR, DR, SC) distinguished by Klauer and Phye (1994). For each of the processing to be trained, the complexity of the presented material increases from concrete objects over pictures to abstract symbols. Further, the 120 problems are divided into 10 lessons with 12 problems per lesson. Each lesson contains at least two basic procedures, and the problems requiring common processing are grouped together within each lesson. As the lessons progress, additional types of processing are introduced. However, the types of processing introduced earlier are reintroduced in later lessons. The last two lessons involve training for all six procedures.

The design of the program is consistent with both transfer-appropriate processing and transfer-appropriate procedures models. By grouping the problems that require common processing, students practice each basic type of processing in a concentrated manner. As a result, the recognition skills as well as solution procedures is developed during the training. This leads to a reduction in the working memory load and is viewed as a progression in developing abstract thinking skills (Case, 1980). Also, the recursive reintroduction of basic types of processing promotes durability and encourages the child to develop an attitude of using long-term memory as a tool for problem-solving.

2.3 Research Validation of the CTC Program

The effectiveness of the Cognitive Training for Children has been evaluated in a number of research studies (Hager & Hasselhorn, 1998; Klauer & Phye, 1994). With a few exceptions, the majority of studies leave little doubt that the program is effective. This section will review 19 studies that are summarized by Klauer and Phye (1994) and/or Hager and Hasselhorn (1998).

To evaluate the effectiveness of the CTC program, all 19 studies have employed a pretest-posttest design, which sometimes is supplemented by a delayed task several months after finishing the program. Methods of analysis employed in these studies are analysis of covariance (ANCOVA) or repeated measures analysis of variance (RM-ANOVA). Hager and Hasselhorn (1996) made a comparison between *F*-tests of RM-ANOVA and *F*-tests of ANCOVA for over one hundred different data sets and found that there was no statistical advantage of one method of analysis over the other (Hager & Hasselhorn, 1998).

Control groups, non-comparative or comparative, are included in almost all the studies evaluating the effectiveness of the CTC program (Hager & Hasselhorn, 1998). Non-comparative evaluations compare the CTC group either to a no-training control group or to a trained control group in which children are trained with another program that has goals quite different from the CTC. However, the settings of implementation in the trained control group, such as duration of implementation and attractiveness of the material, are similar to those of the CTC. The non-comparative evaluation is directed at assessing the program's effectiveness.

Table 2 lists and summaries 16 studies that evaluated the effectiveness of the CTC program by employing a non-comparative evaluation. The effects of the CTC program in improving children's inductive reasoning skills are clearly positive. Of the 16 studies, 13 showed positive effects of the CTC program. Three studies (Beck, Lüttmann, & Rogalla, 1993; Hager & Hasselhorn, 1993a; Kolmsee, 1989) found that the CTC program was not superior to the trained control group and/or no-training control group. Mentally retarded children (Angerhoefer, Kullik, & Masendorf, 1992; Beck, Lüttmann, & Meier, 1995; Masendorf, 1994) and gifted children (Alizadeh, Becker, & Esser, 1990) also benefited from the CTC program.

Three (Bornemann, 1988c, 1992; Johnen, 1988) of the 16 studies applied a follow-up assessment several months after the training to check the durability of training effects. Considerable duration was demonstrated of the impact of the CTC program in problem-solving aptitude, defined as processes reflecting fluid intellectual ability. These results of non-comparative evaluations indicated that the application of the CTC program enhanced most children's performance in tests of fluid intelligence and that there were no negative side-effects associated with the CTC.

Three of the 19 studies (Hager & Hasselhorn, 1993b, 1998; Hasselhorn & Hager, 1995) not included in Table 4 are studies employing a comparative evaluation, which aims at

Table 2. Summary of empirical evidence for the CTC program

Studies	Subjects	CTC Group	Trained Control Group	No Training Group	Effectiveness of the CTC
Alizadeh, Becker, & Esser (1990)	*N*=16; 4.4-6.8 yrs.; kindergarten; gifted children (IQ>115)	*n*=8; 15 sess. (20 min); individual training	—	*n*=8; regular kindergarten activities	yes
Angerhoefer, Kullik, & Masendorf (1992)	*N*=40; 12.4-15.3 yrs.; mentally retarded children	*n*=10; 18 sess. (20 min);	*n*=10; training in multiplication skills	*n*=20; regular classroom activities	yes
Beck, Lüttmann, & Rogalla (1993)	*N*=140; 5-7 yrs.; kindergarten	*n*=72; 10 sess. (20 min); individual training	—	*n*=68; regular kindergarten activities	no
Beck, Lüttmann, & Meier (1995)	*N*=60; 7-10 yrs.; first grade; Turkish children; mentally retarded	*n*=30; 10 sess. (20 min); individual training	—	*n*=30; regular classroom activities	yes
Bornemann (1988a)	*N*=27; 5-6 yrs.; kindergarten	*n*=14; 12 sess. (20 min); pairs of children	—	*n*=13; regular kindergarten activities	yes
Bornemann (1988b)	*N*=20; 5-6 yrs.; kindergarten	*n*=10; 10 sess. (20 min); pairs of children	—	*n*=10; regular kindergarten activities	yes
Bornemann (1988c)	*N*=33; 5-6 yrs.; kindergarten	*n*=11; 10 sess. (20 min); paris of children	*n*=11; 10 sess. (20 min); training in analytic-systematic strategies	*n*=11; regular kindergarten activities	yes
Bornemann (1992)	*N*=279; 6-7yrs.; first grade	*n*=139; 10 sess.; small groups	—	*n*=140; regular classroom activities	yes

Table 2. *(Continued)*

Studies	Subjects	CTC Group	Trained Control Group	No Training Group	Effectiveness of the CTC
Hager & Hasselhorn (1993a)	*N*=32; 7-8 yrs.; deferred from school for one year	*n*=16; 10 sess. (20 min); individual training	*n*=16; metalinguistic training	—	no
Johnen (1988)	*N*=29; 5-6 yrs.; kindergarten	*n*=10; 10 sess. (20 min); individual training	*n*=10; cognition and language training	*n*=9; regular kindergarten activities	yes
Kolmsee (1989)	*N*=30; 6-7 yrs; first grade	*n*=10; 8 sess. (30 min); pairs of children	*n*=9; training in metacognitive skills	*n*=10; regular classroom activities	no
Masendorf (1994)	*N*=30; 11-13yrs.; mentally retarded	*n*=10; 12 sess. (20 min); small groups	*n*=10; spatial training	*n*=10; regular classroom activities	yes
Phye & Sanders (1992)	*N*=10; 8 yrs.; third grade	*n*=10; 10 sess. (20 min); individual training	—	—	yes
Sanders, Phye and Hegland (1991)	*N*=15; 5-6 yrs.; kindergarten;	*n*=8; 10 sess. (20 min); individual training	*n*=7; 10 sess. (20min) training with emergent literacy activities	—	yes
Windgasse-Fischer (1991)	*N*=45; 5-6 yrs.; second grade	*n*=15; 10 sess. (20 min); small groups; top-down strategy (training regularly administered)	*n*=15; 10 sess. (10 min); small groups; bottom-up strategy (tasks presented withminimal assistance)	*n*=15; regular classroom activities	yes
Ziesemer (1989)	*N*=30; 6-7 yrs; first grade	*n*=10; 10 sess. (20 min); pairs of children	*n*=10; 8 sess. (30 min); pairs of children; training in general problem solving	*n*=10; regular classroom activities	yes

examining the superior of two or more programs with the same goals. In comparative evaluations, the children in the trained control group are trained with a competitive program that is also directed to enhance inductive reasoning. The difference between the CTC program and the competitive programs may be in tasks, strategies, and/or instructional methods. For example, Hager and Hasselhorn (1993b) and Hasselhorn and Hager (1995) compared the CTC program with the German version of the Frostig Program of Visual Perception, which is rival to the CTC program with respect to perceptual problems, and found that the CTC program was not worse than, but also not superior to, these competitive cognitive training programs.

2.4 The Web-based Version of the Cognitive Training for Children

WebCT, which was developed at the University of British Colombia, was chosen as the tool for the development of the WCTC program. WebCT requires minimal technical expertise on the part of designer as well as the student. In addition, it incorporates a set of both educational tools, such as quizzes and administrative tools, to assist the instructor in managing student performance and participation.

The WCTC program was designed to teach 4^{th} grade students how to solve the fractions problems through inductive reasoning skills. The program contains 52 different 4^{th} grade fraction problems and is divided into three parts: Introduction, Lessons, and Extra Quizzes. The Introduction helps students identify the differences between *characteristics* (attributes) of the objects and *relationships* among the objects through two examples of each. The first example of the two is object-based, and the second is fraction-based. The factual or conceptual (declarative) knowledge about characteristics (attributes) of objects, relations between objects, and similarity and dissimilarity is elaborated to a child in the Introduction phase. As a result, the child knows that objects can share similar attributes and pairs of objects can share common relations.

The Lesson part contains 6 lessons, each ending with a 10-problem quiz. Table 3 provides an overview of the format in terms of basic types of reasoning processing procedures, the types of problems (object-based or fraction-based), and the order of the presentation for examples within each lesson.

As provided in Table 3, Lesson 1 to 5 contains 3 or 4 examples as well as a quiz, where examples provide the study episode and quizzes provide the practice episode. Lesson 6 contains only a quiz. The first three lessons provide study and practice for all six basic types of inductive reasoning processing, with each lesson containing two types. The examples

Table 3: Overview of the format of the WCTC program

Lesson		GE	DI	CC	RR	DR	SC
1	Example	1O(1) 1F(2)			1O(3) 1F(4)		
	Quiz	5F			5F		
2	Example		1O(1) 1F(2)			1O(3) 1F(4)	
	Quiz		5F			5F	
3	Example			1O(1) 1F(2)			1O(3) 1F(4)
	Quiz			5F			5F
4	Example	1F(1)	1F(2)	1F(3)			
	Quiz	3F	4F	3F			
5	Example				1F(1)	1F(2)	1F(3)
	Quiz				3F	3F	4F
6	Quiz	1F	2F	2F	1F	2F	2F

Types of problems O: Object-based Problems; F: Fraction-based Problems
Order of the presentation for examples within each lesson is provided in parentheses

requiring common reasoning processing are grouped together within each lesson. The last three lessons provide recursive reintroduction of the six processing. The way the problems are arranged is consistent with the transfer-appropriate processing and transfer-appropriate procedures models.

The complexity of the presented examples increases from the initial lessons to the later lessons. This was accomplished by manipulating the types of examples. In the first three lessons, examples are object-based as well as fraction-based. The object-based examples of the procedures always precede the fraction-based example of that same procedure to facilitate learning. Use of concrete symbols, such as objects, should help students understand easier how to solve certain problems. Then, when the general idea is clear, students practice with an abstract fraction-based example, which should further prepare them for the quiz.

The Web-instruction placed on the top of each example page is important in training. It helps children clearly identify and state the problem, tells them that inductive reasoning problem typically require the analysis of similarities and differences, helps them develop a solution strategy as well as control (meta-cognitive monitoring) strategy based on the analysis of similarities and differences, and teaches them how to recognize the problem type and associate it with a paradigm being trained. Here is an example of the Web-instruction for the problem about grouping three things together among five pictorial objects:

> "In this first type of problem, the items in the puzzle have something the same.
>
> To solve these kinds of puzzles, you have to find what characteristic the items have in common. For example, this could be color or shape. When you find the characteristic that the items have the same, you can answer questions

> that ask you to group items.
>
> When you think you know the answer, you should check whether the other items don't have the characteristic you selected. In other words, if you grouped items because they are all red, you have to make sure that the items you didn't select are not red! Only then you will know if you are correct or not!"

The problem type (grouping items) and solution strategy (seeking commonalities of characteristics among objects) are elaborated to children in the instruction. A reverse check is taught as a meta-cognitive monitoring strategy to help students check their answer. Corrective answer and explanation are contained in the answer paragraph below the problem. For this problem, the corrective answer is "the three things that belong together are A and C and D" because "they are all types of shoes." By practicing this example, children learn the particular process of generalization. To help students understand how such problems are "represented" in memory, the instruction also associates the problem type of "grouping items" with the processing of "finding the characteristic that the items have the same" (generalization). A summary of the problem types used in the WCTC program, and the respective cognitive operations as well as monitoring strategies, is presented in Table 4.

Practices of similar processing are repeated in quizzes. The repetition provides an opportunity for the development of strategic knowledge. By doing quizzes, children store procedures and strategies into long-term memory and spontaneously retrieve them as prior knowledge when encountering a new problem. Additionally, the identification of problem types and the respective solution procedures also promotes the development of strategic knowledge.

Table 4. Inductive reasoning processes with respective problem types in the WCTC program

Processes	Question Type	Cognitive Operation	Reverse Check
GE	grouping items	similarity of characteristics	if the other items don't have the characteristic one selected
DI	finding the item that doesn't belong in the group	difference of characteristics	if the items that are left all have the same characteristic.
CC	replaceing one item with another one	similarity & difference in characteristics	if the item that one had to place in the square doesn't have the same characteristic as one of the items in the other squares
RR	1.placing items in an appropriate order 2.adding the item that would come the next 3.selecting an item which would fit in the group	similarity of relationships	if the same relationship exists between all items in the pattern one created
DR	finding the item that doesn't fit in the pattern or messes up the order	difference of relationships	if the same relationship exists between all items left after one take away the item that didn't fit
SC	placing an item in the empty square	similarity & difference in relationships	if the same relationship exists between the items in the top row and bottom row and between the left column and right column.

Students' performance in quizzes will be recorded automatically in the computer. A result page that contains corrective feedback will be available for students after they submit each quiz for grading. The corrective feedback provides a study episode for students. Students' performance in quizzes can be used as an estimate of the development of students' problem-solving abilities with fractions.

Extra Quiz 1 should be taken two weeks after the completion of all lessons, and Extra Quiz 2 must be taken one month after Extra Quiz 1. These two quizzes were designed to assess the durability of the problem-solving abilities.

CHAPTER 3. METHODOLOGY

3.1 Participants

The study was administered in a Mid-west elementary school. Two 4th grade classes were chosen to participate in this study. The principal and teachers of the selected classes had to agree to allow their classes to participate. Parents had to sign the Parental Consent Form to allow their child to participate, and students themselves had to sign the Children's Assent Form to agree to be in this study. As a result, 39 students participated served as participants.

3.2 Experimental Design

The two 4th grade classes were randomly assigned to one of two conditions, training or control. As a result, 20 students served as participants in the training group and 19 in the control group.

Pretest

Since most problems contained in the WCTC program are fraction-based, participants must have some fractions knowledge to play with it. Our study was implemented right after their regular fractions instruction units.

The pretest (see Appendix A) was a form of traditional paper-and-pencil test and was composed of 30 multiple-choice fractions problems. Twenty questions in the pretest were from the test materials contained in the 4th grade textbook and 10 were created by the investigator. Because the 10 questions were created to avoid the ceiling effects, the difficulty of questions was increased by involving more improper and mixed fractions and changing the numerator and/or denominator from one digit to two or three digits. However, the types and expression of the 10 questions are similar to the 20 questions from the textbook. There are 6 types of questions: representation, equivalence, addition, subtraction, simple multiplication, and simplification. Participants were pretested right after their regular fractions instruction units. The pretest provides an estimate of students' knowledge about fractions prior to training. Participants were identified as high or low performers based on their pretest performance.

Training

The training started 5 days after the pretest. Participants in the training group received the WCTC training on the computer over two or three successive days, maximally one hour per day. They were required to finish 6 lessons with quizzes individually and control the pace by themselves. Most participants finished training on the second day, and 3 participants had the last lesson to finish on the third day. On average, it took 20 minutes to finish one lesson and a quiz.

In the beginning of the training, the trainer reminded the participants to read the Web-instruction before solving problems, do the quiz after each lesson, and read the feedback to their solutions. Students' performance in quizzes was recorded on-line automatically.

During the training, participants in the control group played with some 4th grade fractions games on the computer. No inductive reasoning strategies are elaborated in these games. Participants were given one hour per day over two successive days to play with the fractions games. Therefore, the duration of implementation in the control group was similar to the average duration in the training group.

Posttest

All participants were posttested 1 week after training. The procedure of developing the posttest was similar to the pretest. As a result, the posttest (see Appendix B) was a parallel form to the pretest and was also composed of 30 multiple-choice fractions problems. In keeping with practices common to the study of strategic transfer, no reference was made to prior training and practice. Students' performance in posttest can be viewed as an estimate of strategic transfer.

3.3 Hypotheses of the Study

Two main research hypotheses were evaluated in this study. The first hypothesis relates to the effectiveness of the WCTC program. It states that students who receive the WCTC training will have greater improvements from pretest to posttest than those who are in the control group. Hypothesis 2 is related to the comparative effectiveness of the WCTC program to students who are identified as high and low performers. It can be stated in two different ways: 1) it states that, in the training group, low performers will have significantly greater gains than high performers, and 2) it states that the gain differences between the training and control group for low performers will be significantly greater than the differences for high performers.

CHAPTER 4. RESULTS

The pretest and posttest were graded in terms of the number of correct answers. Therefore, the perfect scores for both tests are 30. The reliability coefficient is .8406 for the pretest and .7964 for the posttest. Data were analyzed using the Statistical Package for the Social Sciences (SPSS).

To be consistent with the research hypotheses that the training group would have greater gains than the control group and the low performers would have greater gains than the high performers from pretest to posttest, one-tailed p-values will be used for F-tests of RM-ANOVA.

Research hypothesis 1 states that the WCTC program is effective in improving 4^{th} grade students' performance in fractions. Hence, it was expected that the training group would have greater improvements than the control group from pretest to posttest. Descriptive statistics of the two groups and both tests are given in Table 5.

Inspecting pretest differences, one can see that the training and control group differed somewhat from each other. The control group yielded slightly higher scores with pretest. However, the small differences were not statistically significant (t = 1.059; p=.297). Figure 4

Table 5. Means and standard deviation of the two groups and the two tests

Group		**Prestest**	**Posttest**
Training Group (N=20)	Mean	13.95	16.30
	SD	3.90	4.05
Control Group (N=19)	Mean	15.63	16.68
	SD	5.87	5.79

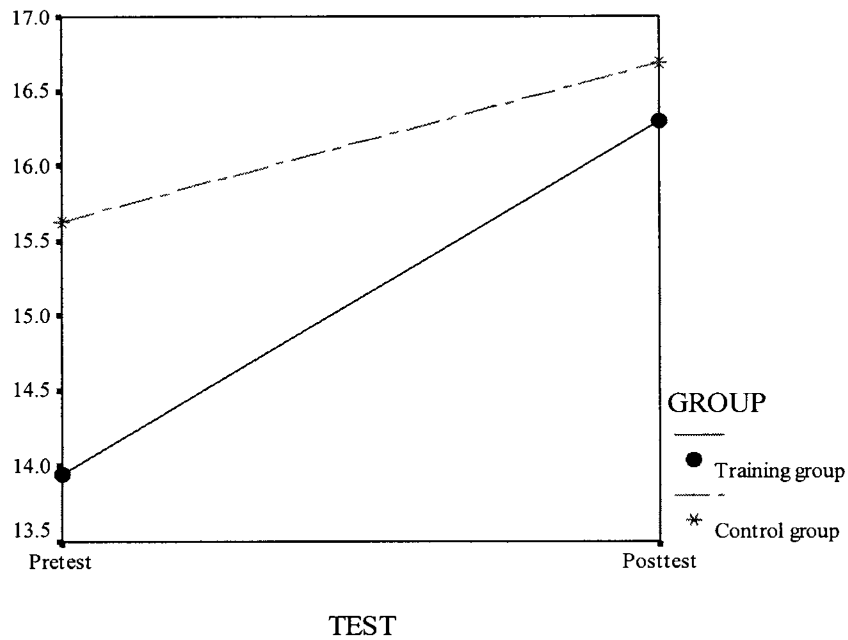

Figure 4. Development of fractions performance of the two groups

presents the development of fractions performance from pretest to posttest for the two groups. As one can see, both the training and control groups improved from pretest to posttest. The control group still yielded slightly higher scores than the training group in the posttest. However, the mean difference (.38) in the posttest was smaller than the pretest (1.68).

With research hypothesis 2 comparable gain differences were expected between high and low performers concerning the effectiveness of the WCTC program. According to frequencies analysis, both groups were divided into two sub-groups (high or low performance level) based on students' fractions performance in the pretest. In Table 6, the means and standard deviations of the two sub-groups are presented for both groups and both tests. As one can see, there were considerable gains for the low performers in the training group and definitely smaller gains for the other three sub-groups.

A 2 × 2 × 2 Repeated measures analysis of variance (RM-ANOVA) was performed by using test as the within-subjects variable and group and performance level as the between-subjects variables. Significant effects were observed for test ($F(1, 35) = 17.937, p < .001$), the test by performance level interaction ($F(1, 35) = 5.042, p < .016$), and the test by group by performance level interaction ($F(1, 35) = 4.440, p < .021$). The main effects of group ($F(1, 35) = .684, p = .207$) and the interaction effects of test by group ($F(1, 35) = 2.591, p = .058$) were not significant.

The nonsignificant interaction effects of test by group indicated that the gain differences between the training and control group were not statistically significant. That is, the WCTC program is not effective, which is not consistent with hypothesis 1.

Although the effectiveness of the WCTC program is not statistically significant in this study, effect size measures were still calculated. Since we are considering the development of fractions performance from pretest to posttest, a corrected effect size measure was reported as $d_{\text{corr}} = d_{\text{posttest}} - d_{\text{pretest}}$ with $d = (M_{\text{TG}} - M_{\text{CG}})/s_{\text{p}}$, where s_{p} is the pooled standard deviation. As a result, a small effect size of $d_{\text{corr}} = .29$ was obtained.

Table 6. Means and standard deviations of the high- and low-performer sub-groups for both groups and both tests

		Training Group		**Control Group**	
		Low (N=10)	**High** (N=10)	**Low** (N=9)	**High** (N=10)
Pretest	Mean	10.80	17.10	10.56	20.20
	SD	2.25	2.23	3.71	2.78
Posttest	Mean	14.90	17.70	11.67	21.20
	SD	2.85	4.72	3.28	3.12

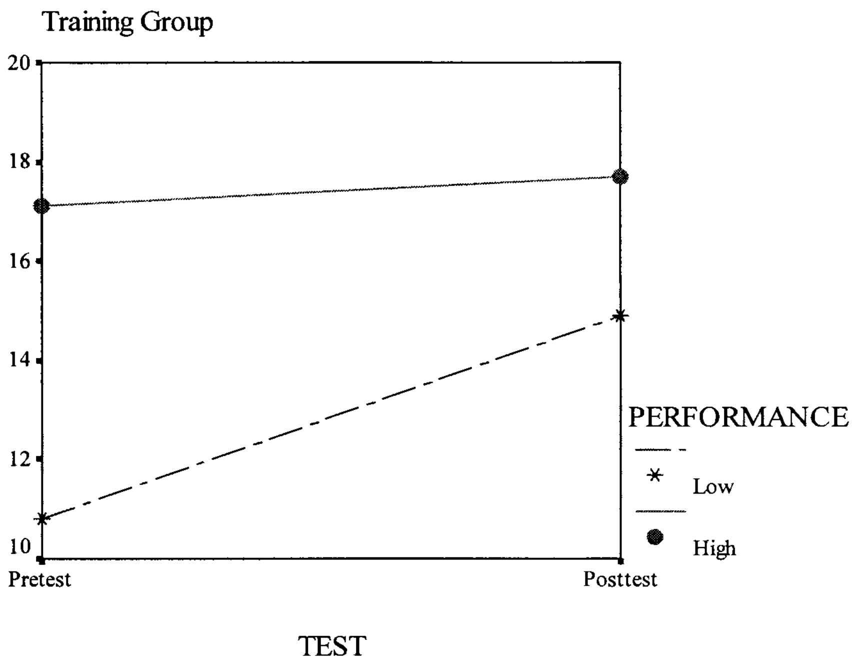

Figure 5. Development of fractions performance for high and low performers in training group

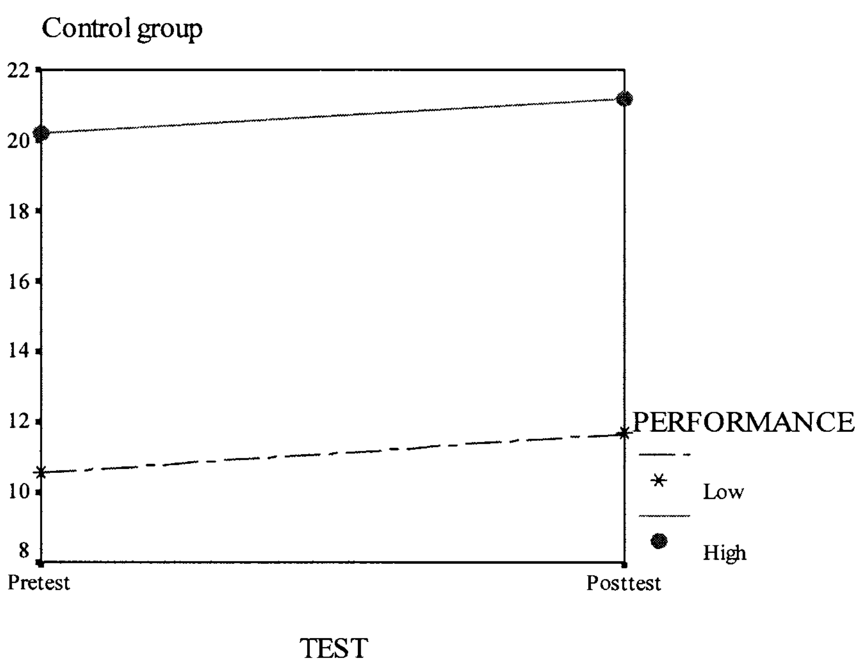

Figure 6. Development of fractions performance for high and low performers in control group

The significant interaction effects between test and performance level indicated that there were gain differences in fractions performance between low and high performers. The significant interaction effects of test by group by performance level indicated that the gain differences between low and high performers were significantly different in different groups. Figure 5 and 6 present the development of fractions performance for high and low performers in the training and control group, respectively. As one can see in Figure 5, there were greater gains for low performers than high performers in the training group. The mean difference between low and high performers decreased from 6.3 in the pretest to 2.8 in the posttest. Figure 6 indicated that high and low performers in the control group improved similarly from pretest to posttest. These results indicated that the WCTC program is more beneficial for low performers.

The significant interaction effects of test by group by performance level can be explained in a different way: the gain differences between the training and control group were different for high and low performers. Figure 7 provides the development of fractions performance in both groups for low performers. One can see that the training group yielded a negligible higher score (.24) than the control group in the pretest. In the posttest the mean difference increased to 3.23 because of greater gains for the training group. Since the interaction effects between test and group were not significant for all participants, a 2 (test) by 2 (group) RM-ANOVA was performed for low performers to see if the gain differences between the training and control group were significant for low performers. As expected, the main effects of test ($F(1, 17) = 28.853, p < .001$) and the interaction effects between test and group ($F(1, 17) = 9.492, p < .001$) were found to be statistically significant. Therefore, it can be concluded that the WCTC program is effective for low performers, although it is not

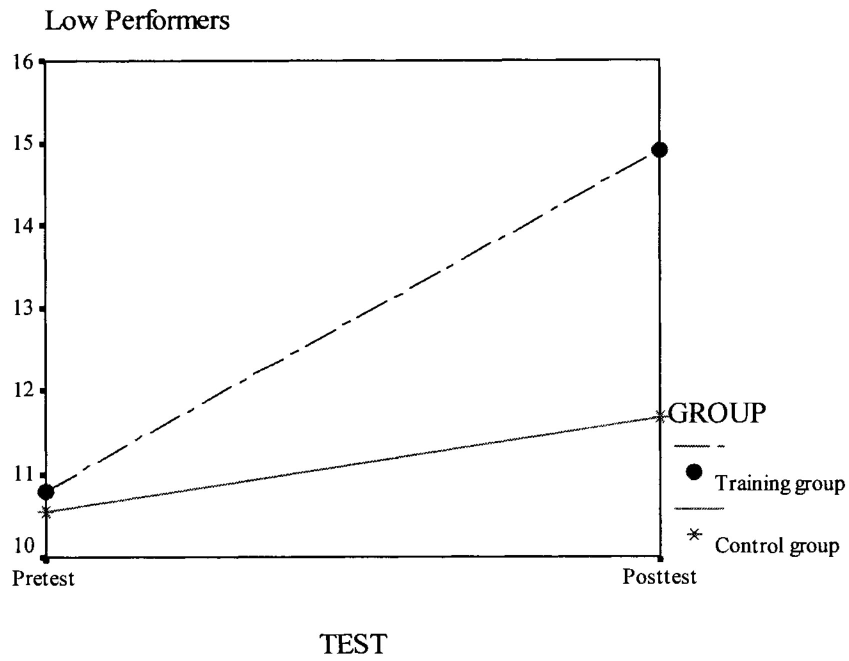

Figure 7. Development of fractions performance for low performers

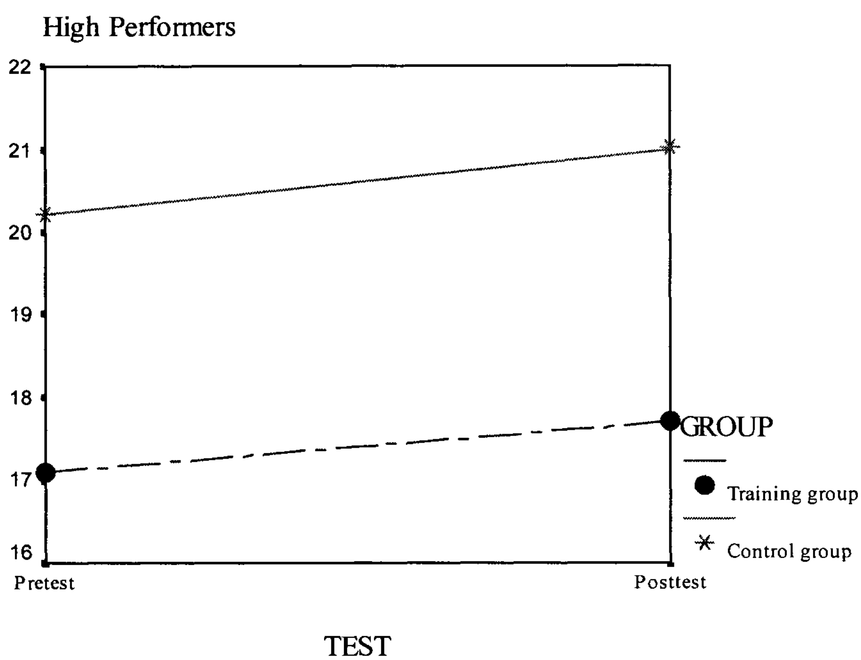

Figure 8. Development of fractions performance for high performers

effective for the whole training group. Figure 8 presents the development of fractions performance in the training and control group for high performers. One can see that the two groups had similar improvements in fractions performance from pretest to posttest, with the control group scoring slightly higher in both tests. The 2 (test) by 2 (group) RM-ANOVA for high performers indicated that there were no significant effects for test ($F(1, 18) = 1.596$, $p = .112$) or the test by group interaction ($F(1, 18) = .100$, $p = .378$). Thus, we can conclude that the WCTC program is not effective for high performers. The effect sizes tell a similar story: for low performers $d_{\text{corr}} = .98$ and for high performers $d_{\text{corr}} = .37$.

On the basis of these results, hypothesis 2, that the WCTC program would be more beneficial for low performers, was retained.

CHAPTER 5. DISCUSSION

5.1 Summary

The WCTC program was designed to help improve 4^{th} grade students' problem-solving abilities in fractions through teaching inductive reasoning skills, especially for those who have difficulty in acquiring sills for fractions through regular classroom instruction. The program has been examined in terms of its technical usability by Verrest (2000). The purposes of this study were to evaluate the instructional effectiveness of the WCTC program as a supplement to regular classroom instruction and the comparative effects of the program on students who are identified as high and low performers in fractions. Participants were two 4^{th} grade classes: one class with 20 students was randomly assigned to the training group to receive training with the WCTC program and another class with 19 students was to the control group. The study was implemented right after the regular fractions instruction units. A pretest-posttest design was employed in this study. Participants were identified as high or low performers based on their pretest performance.

The research hypotheses for this study came from the theoretical basis that inductive reasoning is a central process to higher-order thinking and problem-solving performance, as well as the empirical evidences that the CTC program, the origin of the WCTC program, is effective in improving students' inductive reasoning skills and problem-solving abilities. The research hypotheses were:

1. Participants who receive training with the WCTC program will have greater mean improvement than the untrained ones from pretest to posttest.

2. Participants who are identified as low performers will benefit more from the WCTC program. This hypothesis was tested in two different ways: 1) do low performers gain significantly more than high performers in the training group? and 2) are the gain differences between the two groups significantly higher for low performers than the differences for high performers?

5.2 Conclusions and Discussion

Descriptive statistics indicated that the training group scored slightly lower than the control group in the pretest. The mean difference decreased in the posttest because of greater improvements in fractions performance for the training group. However, RM-ANOVA showed that the improvements differences between the training and control group were not significant. A small effect size (.29) was observed for the WCTC program. Drawing from these results we can conclude that the WCTC program is not effective for the whole training group.

Statistical analysis comparing the effectiveness of the WCTC program on high and low performers indicated that low performers in the training group gained significantly more than their counterparts in the control group. No differences were observed for high performers. That is, the WCTC program is effective in improving low performers' fractions skills, although it is not effective for the whole training group. The results also indicated that low performers gained significantly more than high performers in the training group and no differences were observed between low and high performers in the control group. Drawing from these results, it can be concluded that the WCTC program, as expected, is more beneficial for low performers.

The ineffectiveness of the WCTC program for the whole training group can be explained in terms of some technical factors. One major technical issue that might negatively impact the effectiveness of the program was found in the quiz pages. Answers to the quiz questions were designed as a combination of multiple choices and written responses. For some questions, students can pick from answers provided by the program (multiple choices), and for others, they need to formulate the answers themselves and fill their written responses in the answer boxes. Since written responses sometimes can be expressed in many ways, those questions will have more than one correct answer. For example, for questions requiring students to group similar items, abc, acb, bac, bca, cab, and cba represent the same group, therefore each of them should be the correct answer. The designer of the program has taken this issue into consideration and made the program accept all types of correct answers due to permutation. However, some unanticipated problems arose during the training. For example, some students put a comma or a space among the letters that represent the whole group. As a result, the computer did not give them credit although their answers were correct. Also for questions requiring students to fill in the denominator to complete a fraction with a given numerator, some students entered the whole fraction. Again, they could not get credit for their correct answers. As a result, students were confused when they looked at the correct answers provided by the program. For students who read the results and corrective feedback carefully, some asked for assistance from the investigator, some might have figured out the problems by themselves, and some might just have left it as a problem. For those who reviewed only the scores for each question and skipped the corrective feedback, they might be misled in the following quizzes. In a word, this technical issue negatively impacts the effectiveness of the WCTC program.

Another possible technical problem is that the computers used in this study seem to have inadequate memory for the WCTC program. Some computers froze up when participants clicked the "results" button to look at the grades and corrective feedback for their quizzes. A few computers even froze up when students clicked the "finish" button to submit their quizzes. This might attenuate the measured effects of the program because of the following reasons: 1) In most cases, 4th grade students do not know how to deal with technological problems (Verrest, 2000). Computers that froze up interfered with their use and this might be experienced as very frustrating by students. 2) Students' need for technical assistance was therefore high during the training, which was problematic because only the investigator and the teacher were around. 3) There are no "results" buttons in the homepage. Each result page comes at the end of each quiz, which, in turn, comes at the end of each lesson. Therefore, after computers were restarted, students had to go through the lesson again to access the corresponding result page, which is time-consuming and also boring. To avoid these problems, some participants skipped the "view results" step and directly went to the next lesson after they submitted the quiz, although the investigator kept telling them that they need to read the corrective feedback for their solutions. As we mentioned before, the corrective feedback in the result pages provides the study episode for students and is critical for developing inductive reasoning skills and problem-solving abilities. Skipping this step negatively impacted the effectiveness of the WCTC program.

Another possible factor that might explain the ineffectiveness of the WCTC program is the methodological issue that the sample size in this study was not adequate to detect effectiveness. A power calculator published in the Internet (http://calculators.stat.ucla.edu/powercalc/) was used to calculate the required sample size, using $\alpha = .05$, power of .80 ($\beta = .20$), and common standard deviations of 5 for both groups. Since the research hypothesis is that the training group would have greater improvements than the control group, the one-tailed calculation is used. As a result, the required sample size for detecting the small effect size of .29 is 368, with 184 for each group. Therefore, the sample size of 20 participants in the training group and 19 in the control group was inadequate.

The finding that the WCTC program was more beneficial for low performers is very meaningful because it is consistent with one major goal of *No Child Left Behind* (NCLB) act (http://www.ed.gov/nclb/landing.jhtml?src=pb). Signed by President George W. Bush on January 8, 2002, NCLB is a landmark in educational reform designed to change the culture of America's schools by closing the achievement gap, offering more flexibility, giving parents more options, and teaching students based on what works. In another word, making sure all students, including those who are disadvantaged, achieve academic proficiency is one of NCLB act's accountability provisions. Since the WCTC program decreased the performance gap in fractions between high and low performers, it somewhat contributes to NCLB and can be labeled as a valuable program.

One additional thing that must be mentioned is that students showed high interest and motivation during training. Some of them kept asking the investigator if she would come to their school the next day. This could be because students are more willing to put forth the effort when computers are incorporated (Verrest, 2000).

Overall, the WCTC program is effective for 4^{th} grade students who have difficulty in acquiring skills for fractions through regular classroom instruction, although it is not effective for the whole class. The information gained in this study provides empirical evidence about the instructional effectiveness of the WCTC program. It also adds to the body of knowledge regarding the central role of inductive reasoning in problem-solving.

5.2 Recommendations for Program Modification

To address technical problems with the WCTC program, recommendation for modifying the program are given in this section.

1. To increase the effectiveness of the WCTC program, it is very important to make the program accept all kinds of correct answers for each quiz question. In the current program, the on-line quiz scores do not represent students' real quiz performance because of the technical problem mentioned above that the computer does not recognize all correct answers. In addition, wrong grading may confuse and mislead students, which may negatively impact the effectiveness of the program.

2. The current design is inconvenient for students to review the quiz results because every result page comes at the end of each quiz, which, in turn, comes at the end of each lesson. If students want to access a closed result page, they have to go through the corresponding lesson again. Therefore, it would have been better to put links to result pages in the Lesson homepage and make these links active right after students finished the corresponding quizzes.

3. The current design lacks a "forward-arrow" button on the result pages. Students have to click the "back" button or the small "homepage" button on the top banner to go to the introductory homepage of the program. It would have been better to put a link to the Lesson homepage in the result pages so that students will be able to return to the other Lessons immediately after reviewing the results.

5.4 Limitations

This study has the following investigative limitations

1. Only two classes from one school participated in this study. The sample size was insufficient to detect a small effect size. It also hinders generalization to a larger population.

2. The memory of computers used in this study was not adequate for the WCTC program, which interferes with the training and attenuates the measured effects of the program.

3. There was only one investigator and one teacher around during training. It would have been better if we have more investigators to provide technical assistance for students.

4. The investigator developed the pretest and posttest which was subject to the usual limitations of any test used for the first time.

5.5 Recommendations for Future Research

1. Further study using a larger sample would verify or refute the reliability of the current study and enable the researchers to make generalizations.

2. With adequate sample size, it would be interesting to find out the comparative effects of the WCTC program on students who are identified as high, medium, and low performers.

3. While the computer is capable of recognizing all types of correct answers for quiz questions after program modification and when there are sufficient participants, it would be of interest to do growth curve analysis for quiz performance to examine the development of students' problem-solving abilities with fractions.

4. It would be interesting to do item analysis for pretest and posttest to find out which types of questions would be affected by the WCTC program.

5. Incorporating a qualitative component that investigates students' satisfactions, experiences, and expectation, etc. would provide valuable information for program modification.

6. Finding out if students' performance in inductive reasoning is increased by the WCTC program by using an inductive reasoning test would increase the reliability of the study.

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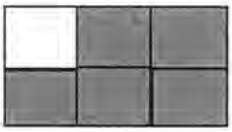
APPENDIX A. PRETEST

Name____ Chapter 9 Pretest

Form B

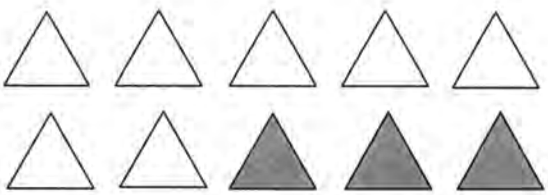
Choose the correct answer for each.

1. Which fraction represents the shaded part of this region?



A. 2/3 B. 1/6
C. 5/6 D. not given

2. Which fractions of these triangles is shaded?



A. 3/10 B. 7/10
C. 1/3 D. 3/7

3. What mixed number is equivalent to 22/4?

A. 11/2 B. 2½
C. 5½ D. 6½

4. What improper fraction is equivalent to 4½?

A. 9/2 B. 8/2
C. 7/2 D. 6/2

5. Which fraction is equivalent to 4/5?

A. 4/20 B. 12/15
C. 2/10 D. 8/5

6. Which fraction is equivalent to 9/12?

A. 1/3 B. 2/3
C. 3/4 D. 5/6

7. Which fraction is equivalent to 2/10?

A. 2/5 B. 3/11
C. 5/30 D. 6/30

8. What is 1/4 of 24?

A. 96 B. 18
C. 6 D. 4

9. What is 1/3 of 15?

A. 45 B. 5
C. 4 D. 3

Add or subtract. Simplify your answer, if possible.

10. 4/15 + 8/15

A. 12/30 B. 12/15
C. 2/5 D. 4/5

Name____ Chapter 9 Pretest

Form B

11. 8/9 - 2/9

A. 2/3 B. 1/3

C. 6/9 D. $1\frac{3}{8}$

Choose the correct answer for each, Simplify your answer, if possible.

12. $3\frac{7}{10} + 1\frac{1}{10}$

A. $4\frac{8}{10}$ B. $4\frac{2}{5}$

C. $5\frac{1}{10}$ D. not given

13. $5\frac{5}{8} - 2\frac{1}{8}$

A. $2\frac{4}{8}$ B. $2\frac{1}{2}$

C. $3\frac{4}{8}$ D. $3\frac{1}{2}$

14. 1/4 + 13/16

A. $1\frac{1}{16}$ B. 7/16

C. 7/10 D. 7/8

15. 2/5 - 1/4

A. 1/5 B. 1/20

C. 3/20 D. 1

16. $2\frac{3}{4} - 2\frac{1}{2}$

A. 0 B. 1

C. 1/2 D. 1/4

17. $3\frac{1}{6} + 1\frac{2}{3}$

A. $4\frac{1}{2}$ B. $4\frac{1}{3}$

C. $4\frac{5}{6}$ D. $4\frac{1}{9}$

18. A snack tray contains 3/4 pound of cheddar cheese and 1/4 pound of brick cheese. How much cheese does the tray contain?

A. 1 pound B. 1/2 pound

C. 1/4 pound D. 2/4 pound

19. In a class, 1/5 of the 20 students were absent. How many students were absent?

A. 1 student B. 4 students

C. 5 students D.20 students

20. Rico rode his bicycle for $2\frac{1}{4}$ hours on Saturday and $1\frac{1}{2}$ hours on Sunday. How many hours did he ride altogether?

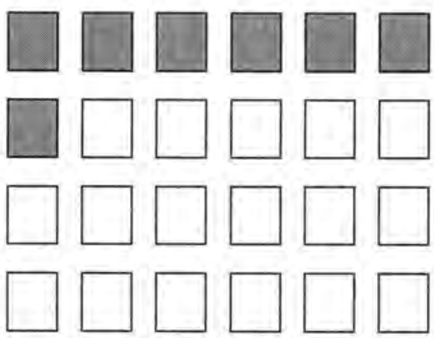
A. $3\frac{3}{4}$ hours B. $3\frac{1}{4}$ hours

C. $3\frac{1}{3}$ hours D. $\frac{1}{8}$ Hours

Name____ Chapter 9 Pretest

Form B

21. Which fraction represents the shaded part of this region?



A. 1/7 B. 13/48
C. 21/72 D. 29/96

22. Which fraction is equivalent to 45/6?

A. 60/8 B. 64/9
C. 88/12 D. 50/11

23. Which mixed number is equivalent to 126/12?

A. $11\frac{1}{3}$ B. $12\frac{2}{3}$
C. $10\frac{3}{8}$ D. $10\frac{1}{2}$

24. What improper fraction is equivalent to $27\frac{2}{3}$?

A. 29/3 B. 54/3
C. 83/3 D. 272/3

25. Which fraction is equivalent to 34/37?

A. 44/47 B. 68/71
C. 108/111 D. 136/148

26. What is 13/16 of 64?

A. 42 B. 52
C. 38 D. 58

27. 1/7 + 7/8

A. 8/15 B. 57/56
C. 56/57 D. 8/56

28. 7/11-1/12

A. 73/132 B. 6/23
C. 6 D. 8

29. 32/5 – 2/3

A. 31/3 B. 15
C. 86/15 D. 34/8

30. Harry walked 14 km to school. A 2/7 of the way to school was a sweet shop. How far was it from Harry's home to the sweet shop?

A. 4km B. 10km
C. 6km D. 12km

APPENDIX B. POSTTEST

Name____ Chapter 9 Posttest

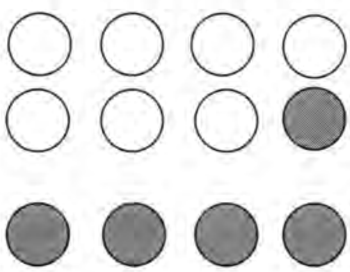
Form B

Choose the correct answer for each.

1. Which fraction represents the shaded part of this region?

A. 3/8
B. 3/10
C. 7/10
D. not given

2. Which fractions of these circles is shaded?



A. 1/5 B. 5/7
C. 5/12 D. 7/12

3. What mixed number is equivalent to 18/4?

A. 9/2 B. 4¼
C. 4½ D. 5½

4. What improper fraction is equivalent to 3½?

A. 4/2 B. 5/2
C. 7/2 D. 31/2

5. Which fraction is equivalent to 3/4?

A. 12/16 B. 6/12
C. 9/8 D. 3/8

6. Which fraction is equivalent to 5/15?

A. 5/3 B. 1/3
C. 3/5 D. 1/5

7. Which fraction is equivalent to 2/6?

A. 6/18 B. 3/12
C. 4/9 D. 1/4

8. What is 1/4 of 20?

A. 80 B. 16
C. 4 D. not given

9. What is 1/3 of 18?

A. 54 B. 9
C. 6 D. 3

Add or subtract. Simplify your answer, if possible.

10. 1/8 + 3/8

A. 1/2 B. 1/4
C. 4/8 D. 4/16

Name____ Chapter 9 Posttest

Form B

Choose the correct answer for each, Simplify your answer, if possible.

11. 11/12 - 5/12

A. $1\frac{1}{3}$ B. 1/2

C. 6/12 D. 1/4

---

12. $2\frac{1}{10}$ + $1\frac{7}{10}$

A. $3\frac{2}{5}$ B. $3\frac{4}{5}$

C. $3\frac{8}{10}$ D. not given

---

13. $4\frac{5}{6}$ - $3\frac{1}{6}$

A. $\frac{2}{3}$ B. $1\frac{4}{6}$

C. $1\frac{2}{3}$ D. $2\frac{1}{3}$

---

14. 5/9 + 2/3

A. 11/9 B. 7/12

C. $1\frac{1}{9}$ D. $1\frac{2}{9}$

---

15. 3/4 - 1/3

A. 1/2 B. 1/6

C. 5/12 D. 2

16. $1\frac{7}{8}$ - $1\frac{1}{2}$

A. 3/8 B. 3/4

C. 1/2 D. 1

---

17. $2\frac{3}{5}$ + $7\frac{1}{10}$

A. $9\frac{4}{15}$ B. $9\frac{7}{10}$

C. $9\frac{1}{5}$ D. $9\frac{1}{2}$

Solve

18. A fruit salad contains 5/8 pound of green graps and 3/8 pound of red grapes. How many pounds of grapes does the fruit salad contain?

A. 1/2 pound B. 1/4 pound

C. 1 pound D. 2/8 pound

---

19. A box contains 24 crayons. If 1/8 of the crayons are broken, how many crayons are broken?

A. 1 crayon B. 3 crayons

C. 4 crayons D.21 crayons

---

20. Robin spent $2\frac{1}{2}$ hours studying on Saturday and $3\frac{1}{4}$ hours on Sunday. How many hours did he study altogether?

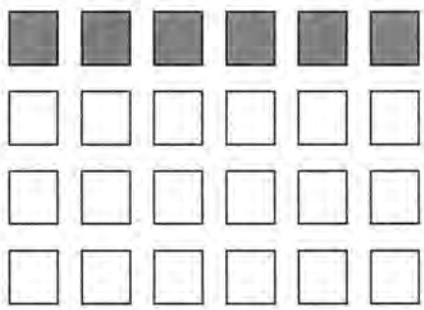
A. $\frac{3}{4}$ hours B. $5\frac{1}{3}$ hours

C. $5\frac{1}{4}$ hours D. $5\frac{3}{4}$ Hours

Name____ Chapter 9 Posttest

Form B

21. Which fraction represents the shaded part of this region?



A. 1/6 B. 13/48
C. 9/36 D. 5/12

---

22. Which fraction is equivalent to 42/9?

A. 56/12 B. 21/3
C. 51/18 D. 14/6

---

23. Which mixed number is equivalent to 123/9?

A. $11\frac{1}{3}$ B. $13\frac{2}{3}$
C. $10\frac{3}{8}$ D. $13\frac{1}{2}$

---

24. What improper fraction is equivalent to $14\frac{2}{3}$?

A. 29/3 B. 44/3
C. 83/3 D. 272/3

25. Which fraction is equivalent to 11/13?

A. 111/133 B. 66/68
C. 110/130 D. 121/143

---

26. What is 13/25 of 50?

A. 42 B. 26
C. 38 D. 13

---

27. 1/6+ 5/7

A. 6/13 B. 37/42
C. 8/13 D. 6/42

---

28. 7/11-3/10

A. 37/110 B. 4/110
C. 6 D. 4

---

29. 21/5 – 3/4

A. 8 B. 18/20
C. 69/20 D. 24/9

---

30. Harry's class had 30 pupils in it. A 2/5 are going on a school trip. How many pupils are **NOT** going on the trip?

A. 12 B. 18 C. 5 D. 25

APPENDIX C. ITEM ANALYSIS TABLE

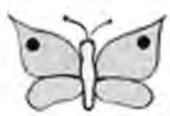
Pretest		Posttest	
Question	Difficulty	Question	Difficulty
1	.79	1	.92
2	1.00	2	.95
3	.72	3	.56
4	.59	4	.62
5	.49	5	.64
6	.69	6	.59
7	.46	7	.59
8	.97	8	.87
9	.87	9	.90
10	.41	10	.62
11	.49	11	.64
12	.33	12	.38
13	.46	13	.62
14	.56	14	.41
15	.26	15	.36
16	.72	16	.67
17	.72	17	.67
18	.92	18	.87
19	.79	19	.85
20	.74	20	.87
21	.31	21	.21
22	.28	22	.03
23	.31	23	.56
24	.25	24	.38
25	.18	25	.46
26	.23	26	.41
27	.25	27	.23
28	.08	28	.13
29	.13	29	.13
30	.08	30	.23

APPENDIX D. THE WEB-BASED VERSION OF THE COGNITIVE TRAINING FOR CHILDREN

Let's solve some problems...

IF YOU WOULD LIKE TO BECOME A PUZZLE GENIUS, THIS IS THE RIGHT PLACE FOR YOU!

- If this is your first visit to this site, click on the butterfly for the introduction.
- When you have finished the introduction, click on the ladybug to get to the 6 lessons of this training.
- The tortoise is for when you have completed all of the lessons and quizzes of the training.



Introduction

Lessons

Extra quizzes

Introduction

Welcome to this training in which you will learn how to solve 6 different types of problems. Some of the problems ask you to look at characteristics of elements in the problem, others ask you to look for the relationship that exists between the elements in the problem. This introduction will help you understand the difference between characteristics and relationships.

Characteristics

Some puzzles in this training can be solved by looking at the characteristics of the items in the puzzle. Characteristics are things that belong to an item. For example, color can be a characteristic or size or shape. Below, you will find an example of a puzzle that needs you to look at characteristics to solve it.

Question:

Look at the picture on the right. There are 12 blocks. It is your task to place the blocks into 4 different groups.

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The blocks can be grouped by color. The correct answer is ABFHK (yellow), CG (green), DI (red), and EJL (blue).

Characteristics

Fractions can also have characteristics. For example, one number can be used in all fractions. It can also be that the number on the top is larger than the number on the bottom or the other way around. Look at the example and see if you understand.

Question:

Look at the picture on the right. There are 6 fractions. It is your task to place the fractions in 3 groups of 2 fractions each. For example, AB CD EF.

$\frac{2}{7}$	$\frac{7}{2}$	$\frac{6}{5}$	$\frac{1}{2}$	$\frac{5}{6}$	$\frac{2}{1}$
A	B	C	D	E	F

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The correct answer is AB, CE and DF. In each group the fractions are opposites of each other.

Relationships

Sometimes you have to find the relationship that exists between items in a problem to be able to solve it. In some way, something happens between the items. For example, items can be ordered from small to large or large to small. Look at the example below and try to find how the items are related to each other.

Question:

Look at the picture on the right. The eight blocks are placed in a pattern. One of the blocks does not fit into the row. Which one?

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The blocks are placed in the order 'blue-yellow-blue-yellow' or 'triangle-square-triangle-square'. This order is messed up at block B and C. One of them does not fit in.

Relationships

Fractions can also be related to each other. As with the picture on the previous page, they can be placed in some kind of order. Look at the fractions below and decide what the relationship between the items is.

Question:

Look at the picture on the right. The fractions are making up a pattern. One of them doesn't fit in. Which fraction?

$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{10}$	$\frac{1}{16}$	$\frac{1}{32}$
A	B	C	D	E	F

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The correct answer is 1/10. From left to right, the bottom number in the fraction is multiplied by two. That is how the fractions are related to each other.

The six lessons...

Below, you find links to 6 lessons that teach you different ways to solve problems. At the end of each lesson, there is a quiz. You don't have to do all lessons today, you can come back any time you want.

You may start with any lesson you want, but it would be best if you start with lesson 1 and then move up. Just scroll down now and click on the ladybug of the lesson you want to take!

Lesson 1

Lesson 2

Lesson 3

Lesson 4

Lesson 5

Lesson 6

Lesson 1

In this lesson, you will learn how to solve two types of problems. It is your task to look at how things are the same (characteristics) and what happens between things (relationships). Click on the arrow below to begin the lesson.

Lesson 1

In this first type of problem, the items in the puzzle have something the same.

To solve these kinds of puzzles, you have to find what characteristic the items have in common. For example, this could be color or shape. When you find the characteristic that the items have the same, you can answer questions that ask you to group items.

When you think you know the answer, you should check whether the other items don't have the characteristic you selected. In other words, if you grouped items because they are all red, you have to make sure that the items you didn't select are not red! Only then you will know if you are correct or not!

Let's look at the example below to see how this works.

Question:

Look at the picture on the right. Three of the things belong together. In some way, they are the same. Which three?

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The three things that belong together are A and C and D. They are all types of shoes.

Lesson 1

Instead of using shoes, the items in a puzzle can be fractions too. In that case, it is your task to find what the fractions have the same. When you find the characteristic that the fractions have in common, you can answer questions about which items belong together or which item could be added.

When you think you know the answer, check whether the fractions that you didn't select don't have that characteristic. Only then you will know if you are correct or not!

Lets try the example below to practice.

Question:

Look at the picture on the right. There are six fractions. It is your task to divide them into two groups of three fractions each. For example, ABC DEF.

$\frac{5}{2}$	$\frac{2}{3}$	$\frac{9}{4}$	$\frac{8}{3}$	$\frac{1}{5}$	$\frac{3}{7}$
A	B	C	D	E	F

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

In group one, there is fraction A and C and D. In all of these fractions, the top number is larger than the bottom number. In group two, you find Band E and F. In all of these fractions, the top number is smaller than the bottom number.

Lesson 1

The second type of problem in this lesson looks at what happens between the items in a puzzle. The same thing happens between the items.

To solve this type of problem, you have to look for what happens between the items. For example, the items can be organized by size or number. When you find what happens between the items, you can answer questions that ask you to place items in the appropriate order or questions that ask you to add the item that would come next.

When you think you know the answer, check if the same relationship exists between all items in the pattern you created. Only then you know if you are correct or not!

Question:

Look at the picture on the right. There are five geese. It is your task to place them in proper order.

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The geese are related to each other by size. You can place them in order from small to large, BDACE, or from large to small, ECADB.

Lesson 1

As with the geese, also fractions can be related to each other. It is your task to find how the fractions are related to each other. For example, the fractions can show a pattern of numbers that are used. When you find that relationship, you can answer questions that ask you to add a fraction at the end or find one that messes up the order.

When you think you know the answer, check whether the same thing happens between all the items you selected. You can also check whether the relationship exists when you start at the end and then move back to the beginning of the pattern. Only then you will know if you are correct or not!

Let's look at the example below to see how it works.

Question:

Look at the picture on the right. The fractions make up a pattern. It is your task to find the fraction that would come next in the pattern.

$$\frac{1}{2} \quad \frac{1}{3} \quad \frac{1}{4} \quad \frac{1}{5} \quad ?$$

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The number on the bottom of each fraction increases with 1. Therefore, the next fraction in the pattern is 1/6.

Lesson 1

Before you go to quiz 1, think about what you just learned! The first step in solving problems is to find out whether the question is about characteristics or relationships. When you know that, you have to find out how the fractions are the same or how they are related to each other!

Quiz Lesson 1

Quiz

Before you go to the quiz, read the hints below carefully!

1) All questions in the quiz are about fractions. Fill in the answers in the white boxes on the screen. Make sure you save each answer before you scroll to the next question. < BR>
2) Some questions in the quiz have a letter printed under each fraction. In those cases, use these letters to answer the question, NOT the fractions.

3) Some questions ask you to type in a fraction as the answer. In those cases, use the "/" to divide the top number of the fraction from the bottom number. For example, 1/5 or 2/7.

4) Some questions ask you to divide the fractions into two different groups. In those cases, don't leave spaces between the fractions in the group. Only leave a space between the two groups. For example, ABC DEF.

You will find the quiz below.

1 Available   0 Due soon

QUIZ LESSON 1

Availability: April 4, 2000 12:00am - Unlimited

Duration: Unlimited   Grade: --- / 100

Attempts: 0 completed, 1 remaining View scores

QUIZ LESSON 1

Name:

Start time: June 9, 2000 12:22pm

Number of questions: 10

Finish Help

Question 1 (10 points)

Using the given fractions, make two groups of three fractions each. For example, ABC DEF.

$\frac{5}{2}$	$\frac{2}{3}$	$\frac{9}{4}$	$\frac{8}{3}$	$\frac{1}{5}$	$\frac{3}{7}$
A	B	C	D	E	F

Answer:

Save answer

Question 2 (10 points)

Which of these fractions

1/4 - 3/3 - 6/2

would fit in the group?

$\frac{1}{3}$ $\frac{4}{3}$ $\frac{2}{3}$ $\frac{5}{3}$ $\frac{7}{3}$

- a. 1/4
- b. 3/3
- c. 6/2

Save answer

Question 3 (10 points)

What fraction would come next in the pattern?

$$\frac{1}{2} \quad \frac{1}{4} \quad \frac{1}{6} \quad \frac{1}{8} \quad ?$$

Answer:

Save answer

Question 4 (10 points)

Which fraction would come next in the pattern?

$$\frac{8}{2} \quad \frac{7}{3} \quad \frac{6}{4} \quad \frac{5}{5} \quad ?$$

Answer:

Save answer

Question 5 (10 points)

Using the given fractions, place them into three groups of two fractions each. For example, AB CD EF.

$\frac{4}{1}$	$\frac{1}{4}$	$\frac{7}{2}$	$\frac{3}{6}$	$\frac{2}{7}$	$\frac{6}{3}$
A	B	C	D	E	F

Answer:

Save answer

Question 6 (10 points)

Using the given fractions, make one group of three fractions. For example, ABC.

$\frac{4}{8}$	$\frac{5}{6}$	$\frac{1}{2}$	$\frac{3}{6}$	$\frac{7}{8}$
A	B	C	D	E

Answer:

Save answer

Question 7 (10 points)

What fraction would come next in the pattern?

$$\frac{2}{4} \quad \frac{5}{7} \quad \frac{6}{8} \quad \frac{9}{11} \quad \frac{10}{12} \quad ?$$

Answer:

Save answer

Question 8 (10 points)

Which fraction comes next?

$$\frac{1}{2} \quad \frac{1}{3} \quad \frac{1}{4} \quad \frac{1}{5} \quad ?$$

Answer:

Save answer

Question 9 (10 points)

Using the given fractions, place them into three seperate groups. For example, AB CD EF.

$\frac{4}{4}$	$\frac{7}{5}$	$\frac{2}{3}$	$\frac{7}{7}$	$\frac{3}{6}$	$\frac{4}{3}$
A	B	C	D	E	F

Answer:

Save answer

Question 10 (10 points)

What fraction would come next in the pattern?

$\frac{7}{10}$ $\frac{6}{10}$ $\frac{5}{10}$ $\frac{4}{10}$?

Answer:

Save answer

Finish Help

Lesson 2

In this lesson, you will learn how to solve two types of problems. It is your task to find which item is different or does not fit into a pattern. Click on the arrow below to begin the lesson.

Lesson 2

In this first type of problem, there is one item that is different. All items have something the same except for one.

To solve these kind of puzzles, you have to find the one item that is different than the others. For example, all items can have the same color except for one. When you find the item that is different, you can answer questions that ask you to find the item that doesn't belong in the group.

When you think you know the answer, you should check whether the items that are left all have the same characteristic. In other words, if you selected the item because of its different color, you have to make sure that the items that are left in the group all have the same color. Only then you will know if you are correct or not!

Let's look at the example below to see how this works.

Question:

Look at the picture on the right. There are four things shown. Which item does not fit in with the others?

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

All tools are used in the garden, except for the telephone. Therefore the correct answer to this question is A. Object A does not fit in with the others.

Lesson 2

Instead of using pictures, the items in a puzzle can be fractions too. In that case, it is your task to find which of the fractions is different. When you find the fraction that is different, you can answer questions about which items does not belong in the group.

When you think you know the answer, check whether the fractions that are left in the group all have the same characteristic. Only then you will know if you are correct or not!

Lets try the example below to practice.

Question:

Look at the picture on the right. There are five fractions. Which one does not belong into the group?

$\frac{5}{2}$	$\frac{7}{6}$	$\frac{4}{3}$	$\frac{3}{8}$	$\frac{4}{1}$
A	B	C	D	E

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

In all fractions the top number is larger than the bottom number, except in fraction D. Therefore, the fraction that does not belong in the group is fraction D, 3/8.

Lesson 2

The second type of problem in this lesson looks at what happens between the items in a puzzle. The same thing happens between the items in the problem except at one place. Something different happens there so the order is messed up.

To solve this type of problem, you have to look for what happens between the items and where this is messed up. For example, the items can be placed in order by shape except at one spot. When you find where something different happens between the items, you can answer questions that ask you to find the one item that doesn't fit in the pattern.

When you think you know the answer, check if the same relationship exists between all items left after you take away the item that didn't fit. Only then you know if you are correct or not!

Question:

Look at the picture on the right. The bugs are placed on a row and form a pattern. Which bug does not fit into the row?

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The bugs are placed on the row based on the number of spots on their back. This order is messed up at bug D.

Lesson 2

As with the ladybugs, also fractions can show a pattern. It is your task to find the one fraction that messes up this pattern. When you find the relationship and the place where it gets messed up, you can answer questions that ask you to find the one that doesn't belong in the pattern or messes up the order.

When you think you know the answer, check whether the same thing happens between the items in the pattern after you take away the one that you think is wrong. Only then you will know if you are correct or not!

Let's look at the example below to see how it works.

Question:
Look at the picture on the right. Which pair does not belong in the group?

(1, A)	(2, B)	(3, S)	(4, D)
A	B	C	D

If you think you know the answer, just scroll down and see whether you were correct!

Answer:
The order in which the items are placed is by number and letter. The order of the letters gets messed up at items C, so that is the pair that does not fit into the group!

QUIZ LESSON 2

Name:

Start time: June 9, 2000 12:23pm

Number of questions: 10

Finish Help

Question 1 (10 points)

Which fraction doesn't belong in the group?

$\frac{5}{2}$	$\frac{7}{6}$	$\frac{4}{3}$	$\frac{3}{8}$	$\frac{4}{1}$
A	B	C	D	E

Answer:

Save answer

Question 2 (10 points)

Which fraction doesn't fit into this pattern?

$\frac{9}{5}$	$\frac{8}{6}$	$\frac{7}{7}$	$\frac{6}{8}$	$\frac{4}{9}$	$\frac{4}{10}$
A	B	C	D	E	F

Answer:

Save answer

uestion 3 (10 points)

Which fraction doesn't belong in this group?

$\frac{9}{2}$	$\frac{8}{4}$	$\frac{4}{7}$	$\frac{10}{3}$	$\frac{3}{2}$
A	B	C	D	E

Answer:

Save answer

Question 4 (10 points)

Which fraction doesn't belong in this group?

$\frac{4}{1}$	$\frac{3}{4}$	$\frac{5}{4}$	$\frac{4}{9}$	$\frac{5}{9}$
A	B	C	D	E

Answer:

Save answer

Question 5 (10 points)

Which pair doesn't belong in this pattern?

(1, A)	(2, B)	(3, S)	(4, D)
A	B	C	D

Answer:

Save answer

Question 6 (10 points)

Which one doesn't belong in the pattern?

A	B	C	D	E	F
$\frac{9}{5}$	$\frac{2}{4}$	$\frac{7}{3}$	$\frac{3}{4}$	$\frac{5}{1}$	$\frac{4}{2}$

Answer:

Save answer

Question 7 (10 points)

Which fraction doesn't belong in the pattern?

A	B	C	D	E	F	G
$\frac{1}{2}$	$\frac{2}{1}$	$\frac{3}{2}$	$\frac{4}{1}$	$\frac{5}{2}$	$\frac{6}{1}$	$\frac{6}{2}$

Answer:

Save answer

Question 8 (10 points)

Which fraction doesn't belong in the group?

A	B	C	D
$\frac{4}{1}$	$\frac{2}{1}$	$\frac{8}{2}$	$\frac{16}{4}$

Answer:

Save answer

Question 9 (10 points)
Which fraction doesn't belong in the group?

$\frac{2}{4}$	$\frac{1}{4}$	$\frac{4}{6}$	$\frac{6}{10}$	$\frac{2}{6}$	$\frac{3}{9}$
A	B	C	D	E	F

Answer:

Save answer

Question 10 (10 points)
Which of the fractions doesn't fit in this pattern?

$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{2}$
A	B	C	D	E

Answer:

Save answer

Finish Help

Lesson 3

In this lesson, you will learn how to solve two types of problems. It is your task to look at how items are both the same and different. You also should look at how items are both related and not related to each other. Click on the arrow below to begin the lesson.

Lesson 3

In this first type of problem, you can make different rows. The items in the top row have something the same, the items in the bottom row have something the same, the items in the left column have something the same, and so do the items in the right column.

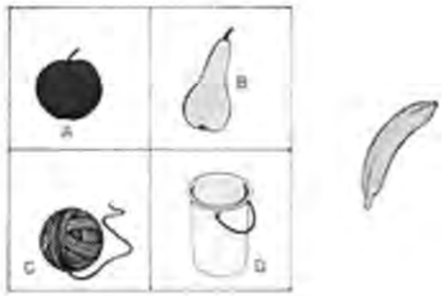
To solve these kinds of puzzles, you have to look at what the items in the different rows have the same. For example, the items in the top and bottom rows can have the same colors, and the items in the left and right column can have the same shape. When you find these characteristics, you can answer questions that ask you to replace one of the items with another item.

When you think you know the answer, you should check whether the item that you had to place in the square doesn't have the same characteristic as one of the items in the other squares. In other words, if you placed the extra item in the right bottom square because it has the same shape as the item in the top right square and the same color as the item in the left bottom square, you have to make sure it doesn't have something the same with the item in the top left square! Only then you will know if you are correct or not!

This sounds kind of difficult so let's look at the example below to see how this works.

Question:

Look at the picture on the right. It is your task to find which item in the square is best replaced by the banana.



If you think you know the answer, just scroll down and see whether you were correct!

Answer:
The correct answer is B. The banana is a fruit so it belongs in the top row. It also is long in shape and not round, so it fits best in the right column.

Lesson 3

Instead of using pictures as in the previous example, the items in a puzzle can be fractions too. In that case, it is your task to find what the fractions in the different rows have the same and what characteristics the extra fraction has that should be placed in one of the squares. When you find all of that information, you will be able to answer questions that ask you to replace on of the fractions in the squares by another fraction.

When you think you know the answer, check whether the fraction that you placed in the square does not fit in any of the other squares. Only then you will know if you are correct or not!

Let's try the example below to practice.

Question:

Look at the picture on the right. Which fraction could be replaced by 2/3?

If you think you know the answer, just scroll down and see whether you were correct!

$\frac{3}{3}$ A	B $\frac{1}{3}$
C $\frac{4}{4}$	D $\frac{2}{4}$

Answer:

The correct answer is B. If you look at the top row, you see that both fractions have a 3 at the bottom. If you look in the columns, the right column is the one that has fractions that have a value of smaller than 1.

Lesson 3

In this second type of problem, you can make different rows again. Between the items in the different rows something happens. The same thing needs to happen between the items in the other rows.

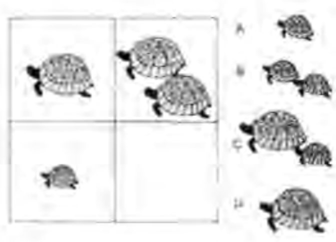
To solve these kind of puzzles, you have to look at what happens between the items in the different rows. What happens between the items in the top row must happen between the items in the bottom row. Also, the relationship that exists between the items in the left column, must also exists between the items in the right column. When you find all those relationships, you will be able to answer questions that ask you to place an item in the empty square.

When you think you know the answer, you should check whether the same thing happens between the items in the top row and bottom row and between the left column and right column. Only then you will know if you are correct or not!

This sounds kind of difficult so let's look at the example below to see how this works.

Question:

Look at the picture on the right. Which picture on the right best fits into the empty square?



If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The correct answer is B. From left to right you add one tortoise, and from top to bottom, you reduce the size.

Lesson 3

Instead of using tortoise, the items in the squares can be fractions too. In that case it is your task to find what happens between the fractions in the different rows. When you find that out, you can answer questions that ask you to place a fraction in the empty square.

When you think you know the answer, check whether the relationship is the same between the fractions in all rows. Only then you know if you are correct or not!

Let's try the example below to practice.

Question:
Look at the picture on the right. Which fraction can replace the * in the picture?

$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{6}$	*
$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{7}$	$\frac{1}{9}$

If you think you know the answer, just scroll down and see whether you were correct!

Answer:
The correct answer is 1/8. If you look from left to right, the bottom number of the fraction is plus 2. From top to bottom, the change is plus 1.

QUIZ LESSON 3

Name:

Start time: June 9, 2000 12:24pm

Number of questions: 10

Finish Help

Question 1 (10 points)

What fraction replaces the * in the pattern below?

$$\frac{1}{2} : \frac{2}{2} :: \frac{2}{2} : \frac{3}{2} :: \frac{3}{2} : *$$

Answer:

Save answer

Question 2 (10 points)

Which of the four numbers represents the largest amount?

$\frac{1}{2}$	0.68	25%	$\frac{5}{5}$
A	B	C	D

Answer:

Save answer

Question 3 (10 points)

Which fraction could be replaced by 2/3?

A $\frac{3}{3}$	B $\frac{1}{3}$
C $\frac{4}{4}$	D $\frac{2}{4}$

Answer:

Save answer

Question 4 (10 points)

What number under 10 could replace the * to make this a true statement?

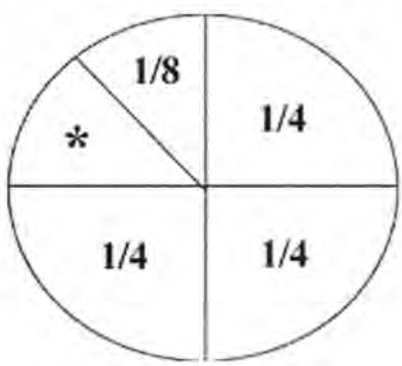
$$\frac{1}{2} > \frac{1}{3} \quad ; \quad \frac{1}{3} > \frac{1}{*}$$

Answer:

Save answer

Question 5 (10 points)

What fraction should replace the * in this picture?



Answer:

Save answer

Question 6 (10 points)

What fraction could replace the * in the picture?

$\frac{1}{2}$	$\frac{1}{4}$
$\frac{1}{4}$	*

Answer:

Save answer

Question 7 (10 points)

What fraction could be best replaced by 8/4?

$\frac{10}{2}$ A	B $\frac{9}{5}$
C $\frac{2}{4}$	D $\frac{1}{3}$

Answer:

Save answer

Question 8 (10 points)

What fraction would best replace the * in the picture?

$\frac{6}{6}$	$\frac{2}{2}$
$\frac{5}{5}$	*

Answer:

Save answer

Question 9 (10 points)

Which of the fractions in the square could be replaced by 6/4?

$\frac{7}{9}$ A	B $\frac{4}{8}$
$\frac{5}{3}$ C	D $\frac{8}{2}$

Answer:

Save answer

Question 10 (10 points)

Which fraction in the square could be replaced by 2/4?

$\frac{8}{4}$ A	B $\frac{3}{4}$
$\frac{6}{3}$ C	D $\frac{2}{3}$

Answer:

Save answer

Lesson 4

In this lesson, you will repeat some of the things you have learned in lesson 1, 2 and 3. It is your task to find out how fractions are the same, are different, or are both the same and different. Click on the arrow below to begin the lesson.

Lesson 4

Some of the questions in the quiz ask you to group fractions. To do so, you need to look at how the fractions are the same.

Look at the example below.

Question:

Look at the picture on the right. There are six fractions. It is your task to divide them into two groups of three fractions each. For example, ABC DEF.

A	B	C	D	E	F
$\frac{5}{2}$	$\frac{2}{3}$	$\frac{9}{4}$	$\frac{8}{3}$	$\frac{1}{5}$	$\frac{3}{7}$

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

In group one, there is fraction A and C and D. In all of these fractions, the top number is larger than the bottom number. In group two, you find Band E and F. In all of these fractions, the top number is smaller than the bottom number.

Lesson 4

Other questions in the quiz ask you to find the fraction that doesn't fit in the group. To do so, you need to look at which fraction is different than the others.

Look at the example below.

Question:

Look at the picture on the right. There are five fractions. Which one does not belong into the group?

$\frac{5}{2}$ A $\quad \frac{7}{6}$ B $\quad \frac{4}{3}$ C $\quad \frac{3}{8}$ D $\quad \frac{4}{1}$ E

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

In all fractions the top number is larger than the bottom number, except in fraction D. Therefore, the fraction that does not belong in the group is fraction D, 3/8.

Lesson 4

Finally, there are some questions that want you to replace one fraction with another fraction. You find an example of this below. To do so, you have to look at the characteristics of the fractions in the rows and squares and at the characteristics of the fraction to be placed in.

Look at the example below.

Question:

Look at the picture on the right. Which fraction could be replaced by 2/3?

If you think you know the answer, just scroll down and see whether you were correct!

$\frac{3}{3}$ A	B $\frac{1}{3}$
C $\frac{4}{4}$	D $\frac{2}{4}$

Answer:

The correct answer is B. If you look at the top row, you see that both fractions have a 3 at the bottom. If you look in the columns, the right column is the one that has fractions that have a value of smaller than 1.

QUIZ LESSON 4

Name:

Start time: June 9, 2000 12:24pm

Number of questions: 10

Finish Help

Question 1 (10 points)

Which decimal doesn't belong in the group?

0.256	0.100	0.3	0.111	0.001
A	B	C	D	E

Answer:

Save answer

Question 2 (10 points)

The fraction 4/8 would fit in which box?

$\frac{4}{2}$ A	B $\frac{2}{6}$
C $\frac{10}{5}$	D $\frac{3}{7}$

Answer:

Save answer

Question 3 (10 points)

What fraction doesn't belong in the group?

$\frac{1}{5}$	$\frac{1}{7}$	$\frac{2}{5}$	$\frac{3}{5}$	$\frac{1}{2}$	$\frac{3}{7}$	$\frac{4}{7}$
A	B	C	D	E	F	G

Answer:

Save answer

Question 4 (10 points)

Using the given fractions, make one group of three fractions. For example, ABC.

$\frac{3}{9}$	$\frac{2}{6}$	$\frac{1}{1}$	$\frac{3}{1}$	$\frac{1}{3}$
A	B	C	D	E

Answer:

Save answer

Question 5 (10 points)

The fraction 9/3 would fit in which box?

2 (A)	(B) $\frac{4}{2}$
3 (C)	(D) $\frac{2}{3}$

Answer:

Save answer

Question 6 (10 points)

Using the given fractions, place them into three different groups.For example, AB CD EF.

A	B	C	D	E	F
$\frac{2}{7}$	$\frac{7}{2}$	$\frac{6}{5}$	$\frac{1}{2}$	$\frac{5}{6}$	$\frac{2}{1}$

Answer:

Save answer

Question 7 (10 points)

Which fraction doesn't belong in the group?

A	B	C	D	E	F
$\frac{3}{2}$	$\frac{4}{3}$	$\frac{7}{4}$	$\frac{5}{2}$	$\frac{7}{6}$	$\frac{2}{5}$

Answer:

Save answer

Question 8 (10 points)

Which fraction doesn't belong in this group?

A	B	C	D	E
$\frac{20}{40}$	$\frac{15}{30}$	$\frac{10}{20}$	$\frac{10}{5}$	$\frac{1}{2}$

Answer:

Save answer

Question 9 (10 points)

Using the given fractions, make one group of three fractions. For example, ABC.

$\frac{6}{2}$	$\frac{5}{7}$	$\frac{1}{5}$	$\frac{9}{6}$	$\frac{7}{3}$
A	B	C	D	E

Answer:

Save answer

Question 10 (10 points)

Which of the fractions in the square could be replaced by 1/2?

$\frac{4}{8}$ A	B $\frac{6}{6}$
C $\frac{3}{6}$	D $\frac{5}{5}$

Answer:

Save answer

Finish Help

Lesson 5

In this lesson, you will repeat some of the things you have learned in lesson 1, 2 and 3. It is your task to find out what happens between the fractions in the problems. Click on the arrow below to begin the lesson.

Lesson 5

Some of the questions in the quiz ask you to add a fraction at the end of a pattern. To do so, you have to look at what happens between the fractions in the pattern.

Look at the example below.

Question:

Look at the picture on the right. The fractions make up a pattern. It is your task to find the fraction that would come next in the pattern.

$$\frac{1}{2} \quad \frac{1}{3} \quad \frac{1}{4} \quad \frac{1}{5} \quad ?$$

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The number on the bottom of each fraction increases with 1. Therefore, the next fraction in the pattern is 1/6.

Lesson 5

Some other questions ask you to look for the fraction that doesn't belong in the pattern. To do so, you need to look for what happens between the fractions in the pattern.

Look at the example below.

Question:

Look at the picture on the right. Which pair does not belong in the group?

(1, A)	(2, B)	(3, S)	(4, D)
A	B	C	D

If you think you know the answer, just scroll down and see whether you were correct!

Answer:

The order in which the items are placed is by number and letter. The order of the letters gets messed up at items C, so that is the pair that does not fit into the group!

Lesson 5

Finally, there are some questions that want you to place a fraction in the empty square in a row. To do so, you need to look at what happens between the fractions in the other row and column. The same thing needs to happen in the row and column with the empty square.

Look at the example below.

Question:
Look at the picture on the right. Which fraction can replace the * in the picture?

$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{6}$	*
$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{7}$	$\frac{1}{9}$

If you think you know the answer, just scroll down and see whether you were correct!

Answer:
The correct answer is 1/8. If you look from left to right, the bottom number of the fraction is plus 2. From top to bottom, the change is plus 1.

QUIZ LESSON 5

Name:

Start time: June 9, 2000 12:25pm

Number of questions: 10

Finish Help

Question 1 (10 points)

Which fraction should come next in the pattern?

$$\frac{5}{3} \quad \frac{6}{4} \quad \frac{7}{5} \quad \frac{8}{6} \quad ?$$

Answer:

Save answer

Question 2 (10 points)

What number should replace the * in this analogy?

$$\frac{8}{4} : 2 \quad :: \quad \frac{6}{2} : *$$

Answer:

Save answer

Question 3 (10 points)

Which fraction doesn't belong in this pattern?

$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{10}$	$\frac{1}{16}$	$\frac{1}{32}$
A	B	C	D	E	F

Answer:

Save answer

Question 4 (10 points)

What two fraction should replace the * and ? in the picture?

$\frac{1}{3}$	$\frac{1}{4}$	*	$\frac{1}{6}$
$\frac{2}{6}$	$\frac{2}{8}$	?	$\frac{2}{12}$

Answer:

Save answer

Question 5 (10 points)

What fraction should replace the * in this picture?

$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{6}$	*
$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{7}$	$\frac{1}{9}$

Answer:

Save answer

Question 6 (10 points)

What fraction should replace the * in this picture?

$\frac{1}{1}$	*	$\frac{16}{16}$	$\frac{64}{64}$
$\frac{2}{2}$	$\frac{8}{8}$	$\frac{32}{32}$	$\frac{128}{128}$

Answer:

Save answer

Question 7 (10 points)

What fraction would come next in this pattern?

$$\frac{4}{3} \quad \frac{3}{4} \quad \frac{5}{4} \quad \frac{4}{5} \quad \frac{6}{5} \quad \frac{5}{6} \quad ?$$

Answer:

Save answer

Question 8 (10 points)

Which fraction messes up the order?

$\frac{4}{8}$	$\frac{5}{7}$	$\frac{6}{5}$	$\frac{7}{5}$	$\frac{8}{4}$
A	B	C	D	E

Answer:

Save answer

Question 9 (10 points)

Which fraction doesn't belong in this pattern?

$\frac{1}{2}$	$\frac{2}{4}$	$\frac{3}{6}$	$\frac{4}{8}$	$\frac{3}{4}$
A	B	C	D	E

Answer:

Save answer

Question 10 (10 points)

Which fraction would come next in the pattern?

$$\frac{1}{5} \quad \frac{3}{7} \quad \frac{4}{8} \quad \frac{6}{10} \quad \frac{7}{11} \quad ?$$

Answer:

Save answer

Finish Help

Lesson 6

In this lesson, you will repeat what you have learned in all the other lessons. There are no new problems to practice with, only some instructions that help you do well on the quiz. Just click on the arrow below for those instructions.

QUIZ LESSON 6

Name:

Start time: August 8, 2004 8:25pm

Number of questions: 10

Finish Help

Question 1 (10 points)

Which fraction doesn't belong in this group?

$$\frac{1}{10} \quad \frac{2}{9} \quad \frac{3}{8} \quad \frac{5}{7} \quad \frac{5}{6}$$

A B C D E

Answer:

Save answer

Question 2 (10 points)

What fraction should replace the * in this analogy?

$$\frac{3}{7} : \frac{5}{9} \quad :: \quad \frac{2}{4} : *$$

Answer:

Save answer

Question 3 (10 points)

Which fraction doesn't belong in this group?

$\frac{10}{5}$	$\frac{8}{2}$	$\frac{6}{3}$	$\frac{1}{2}$	$\frac{3}{6}$	$\frac{2}{8}$
A	B	C	D	E	F

Answer:

Save answer

Question 4 (10 points)

Using the given fractions, make one group of four fractions?

$\frac{1}{2}$	$\frac{2}{4}$	$\frac{3}{7}$	$\frac{5}{10}$	$\frac{5}{9}$	$\frac{4}{8}$
A	B	C	D	E	F

Answer:

Save answer

Question 5 (10 points)

Which fraction comes next in the pattern?

$$\frac{4}{1} \quad \frac{5}{2} \quad \frac{6}{3} \quad \frac{7}{4} \quad \frac{8}{5} \quad ?$$

Answer:

Save answer

Question 6 (10 points)

Which fraction does not belong in the group?

$\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{10}$
A	B	C	D	E	F

Answer:

Save answer

Question 7 (10 points)

Which fraction does not belong in the pattern?

$\frac{1}{2}$	$\frac{2}{4}$	$\frac{3}{5}$	$\frac{4}{8}$	$\frac{5}{10}$
A	B	C	D	E

Answer:

Save answer

Question 8 (10 points)

Which fraction in the square could be replaced by 5/6?

$\frac{1}{3}$ A	B $\frac{9}{3}$
C $\frac{2}{6}$	D $\frac{8}{6}$

Answer:

Save answer

Question 9 (10 points)

Which fraction in the square could be replaced by 3/5?

$\frac{7}{5}$ A	B $\frac{8}{6}$
C $\frac{1}{5}$	D $\frac{2}{6}$

c

Answer:

Save answer

Question 10 (10 points)

Which fraction could replace the * in the picture below?

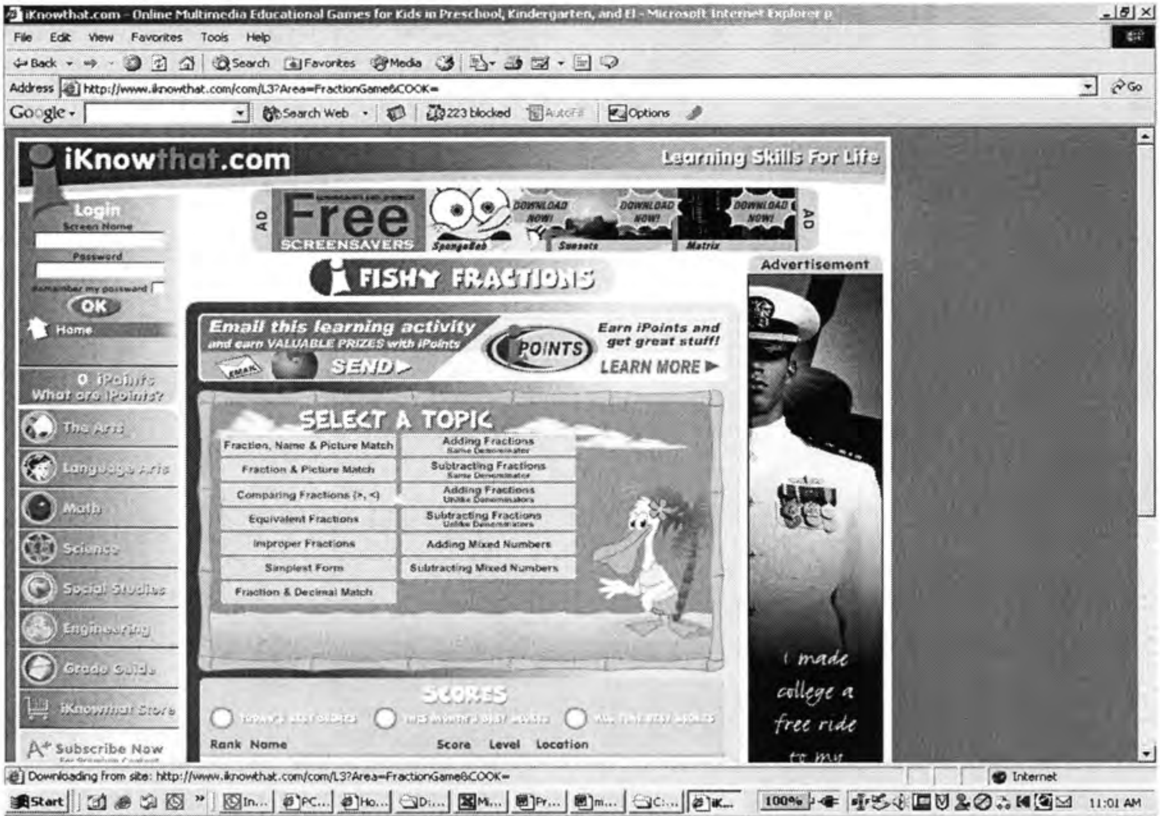
$\frac{1}{5}$	$\frac{1}{10}$
$\frac{1}{10}$	*

Answer:

Save answer

Finish Help

APPENDIX E. MATERIALS USED IN THE CONTROL GROUP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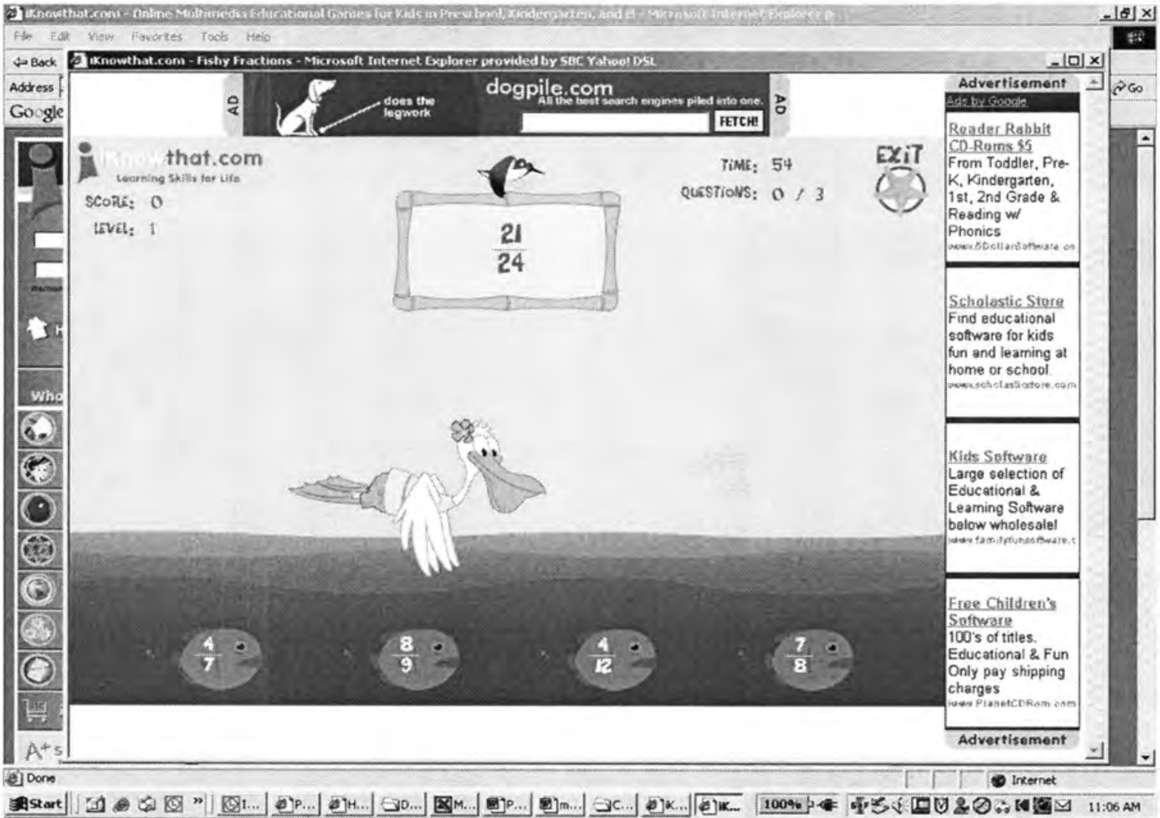
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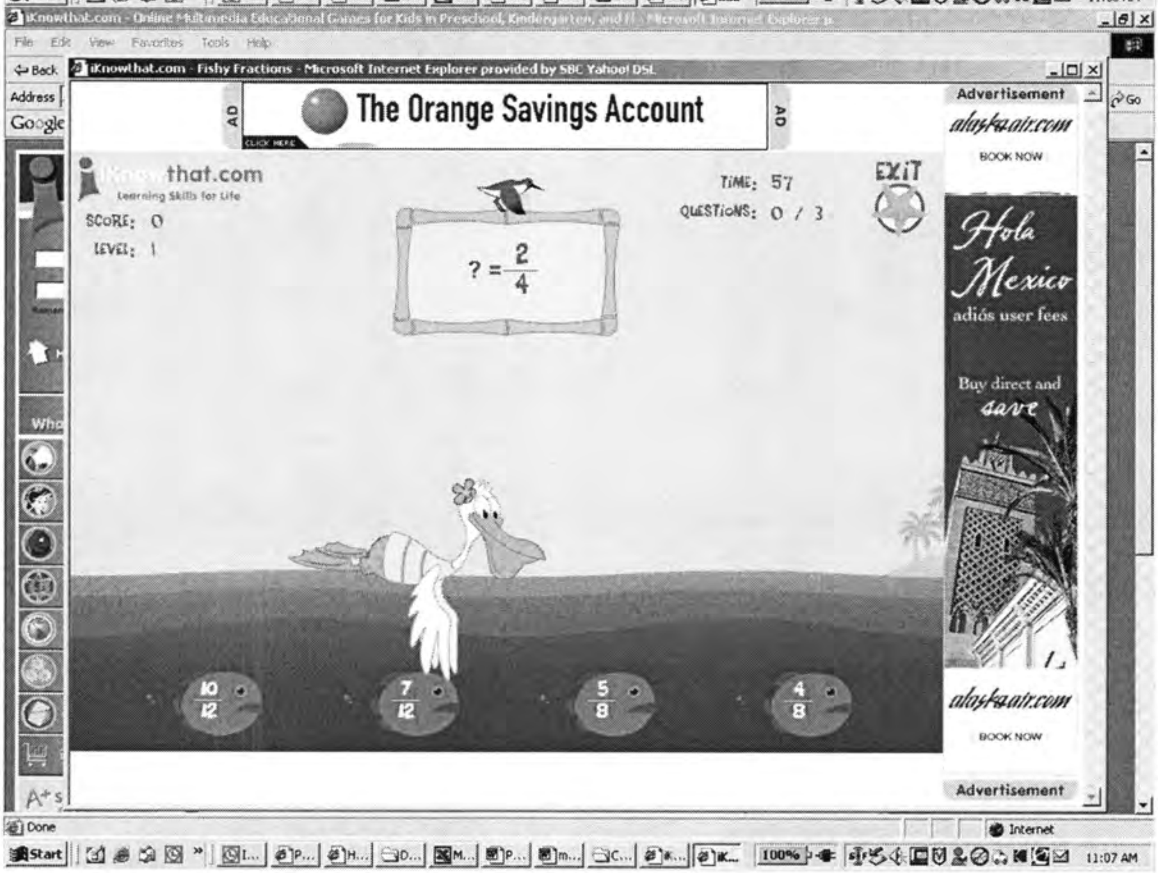
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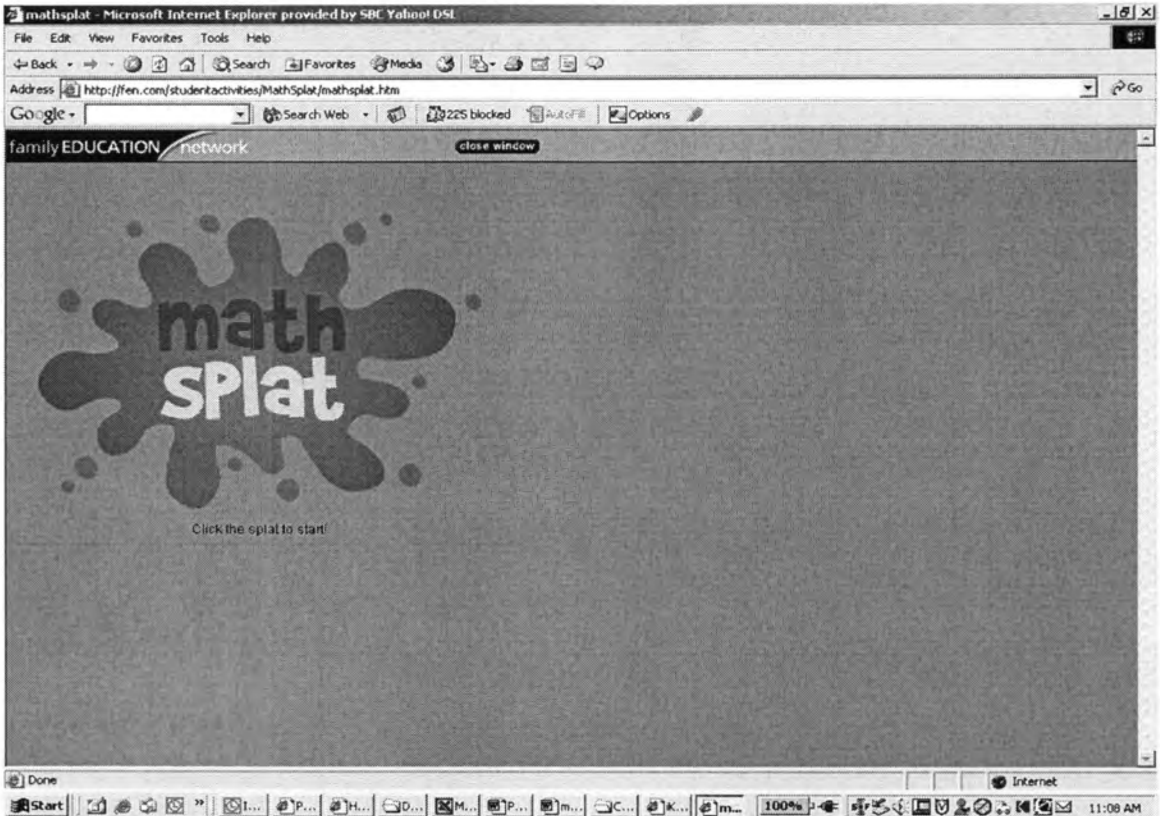
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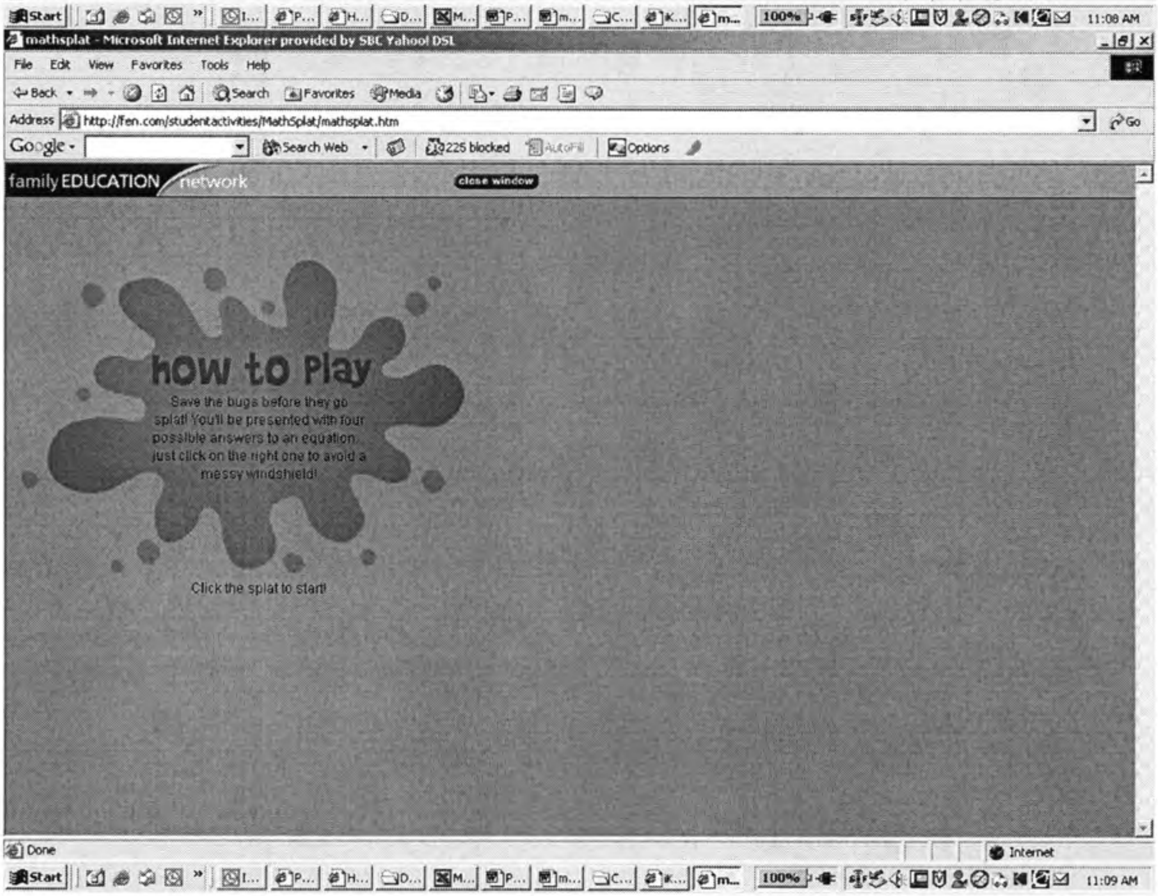
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Save the bugs before they go splat! You'll be presented with four possible answers to an equation. Just click on the right one to avoid a messy windshield!
Click the splat to start!
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Internet
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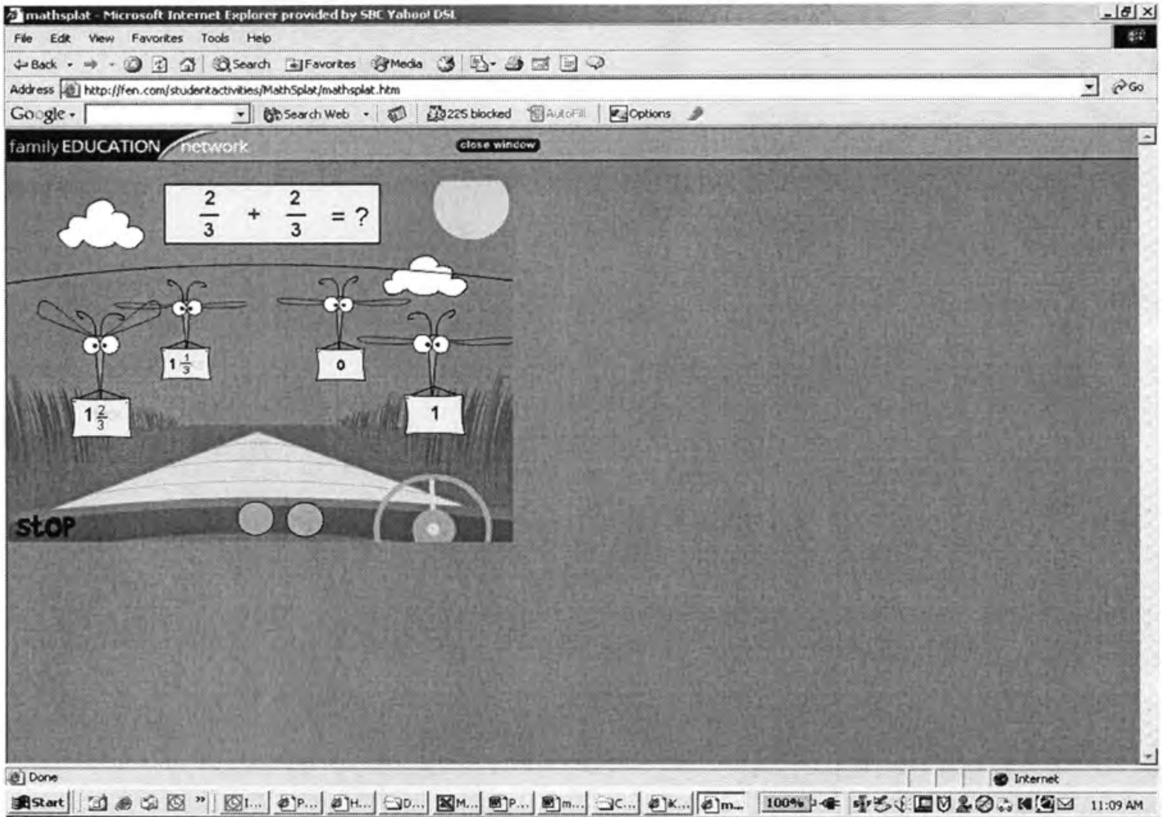
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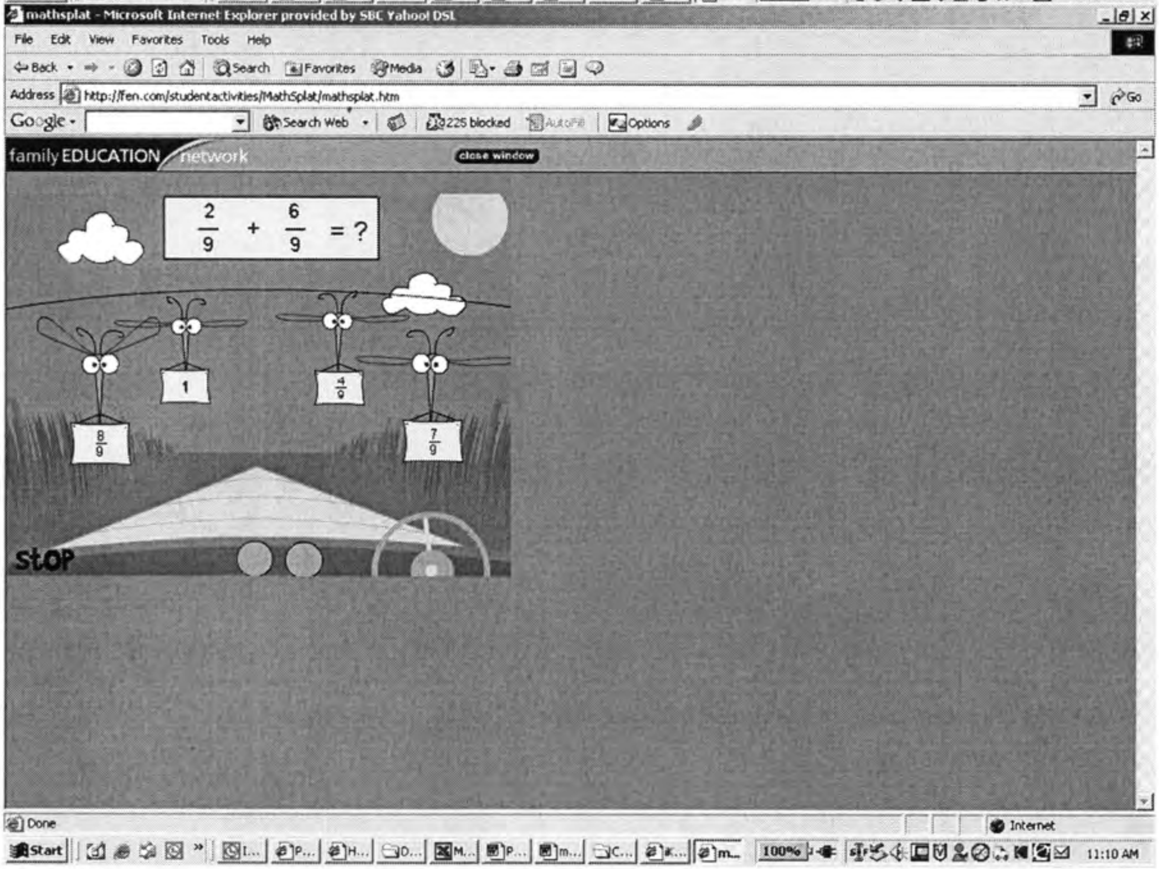
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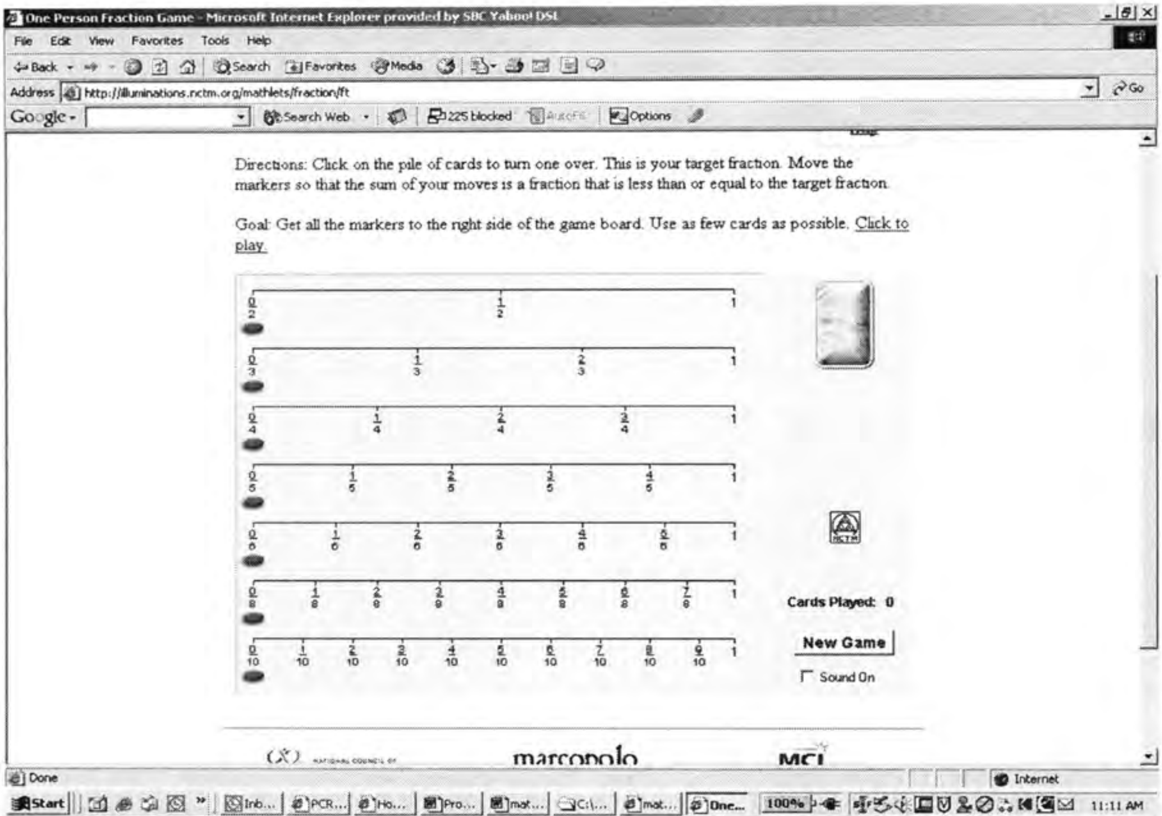
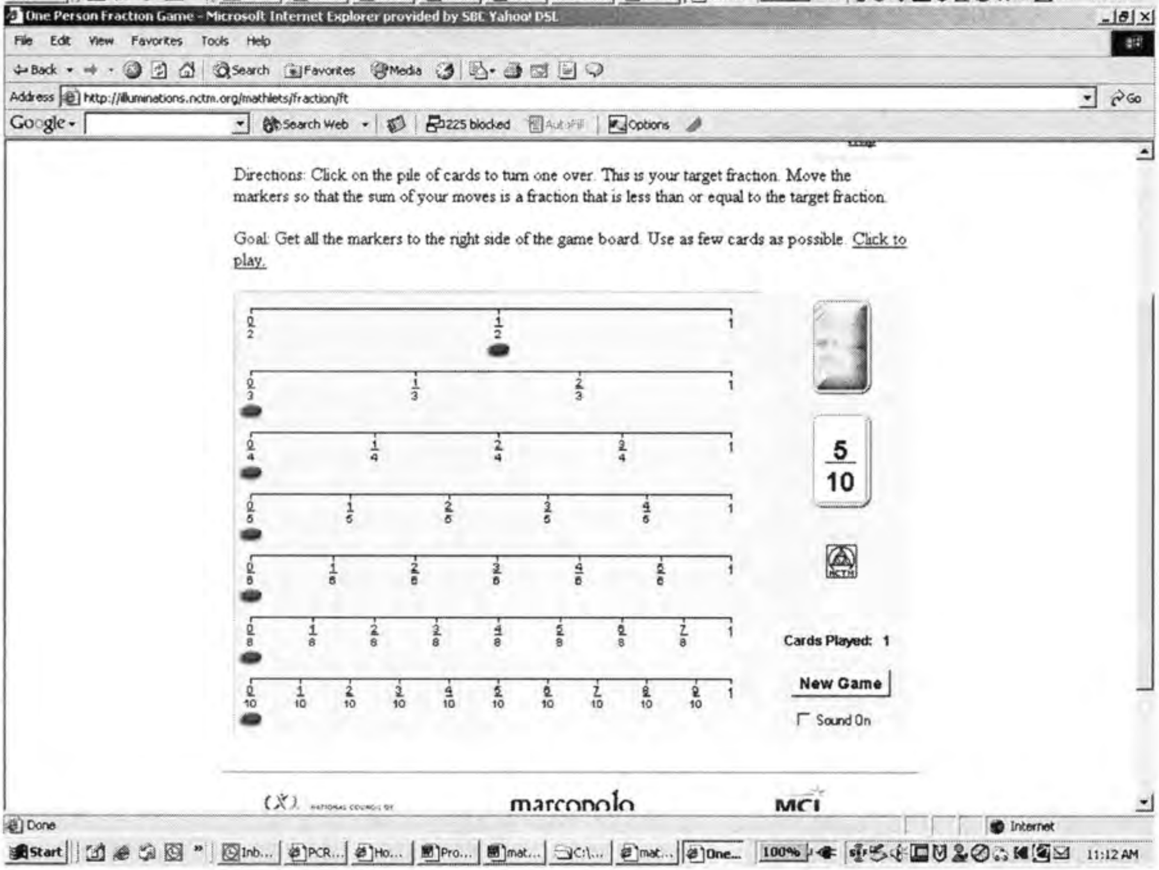

One Person Fraction Game - Microsoft Internet Explorer provided by SBC Yahoo! DSL
Address http://illuminations.nctm.org/mathlets/fraction/ft
Directions: Click on the pile of cards to turn one over. This is your target fraction. Move the markers so that the sum of your moves is a fraction that is less than or equal to the target fraction.
Goal: Get all the markers to the right side of the game board. Use as few cards as possible. Click to play.
Cards Played: 0
New Game
Sound On
marcopolo
MCI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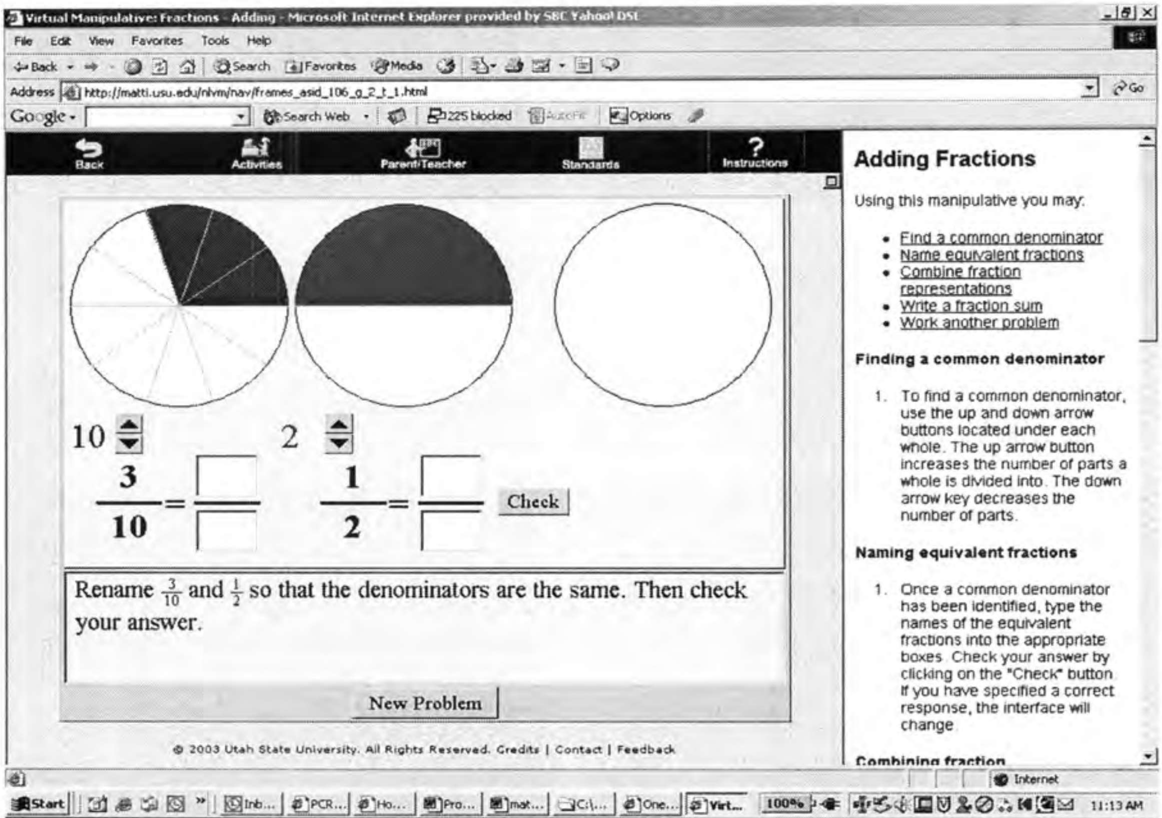
Address http://illuminations.nctm.org/mathlets/fraction/ft
Directions: Click on the pile of cards to turn one over. This is your target fraction. Move the markers so that the sum of your moves is a fraction that is less than or equal to the target fraction.
Goal: Get all the markers to the right side of the game board. Use as few cards as possible. Click to play.
5/10
Cards Played: 1
New Game
Sound On
marcopolo
MCI


Virtual Manipulative: Fractions - Adding - Microsoft Internet Explorer provided by SBC Yahoo! DSL
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Back
Activities
Parent/Teacher
Standards
Instructions
10
2
3/10 =
1/2 =
Check
Rename 3/10 and 1/2 so that the denominators are the same. Then check your answer.
New Problem
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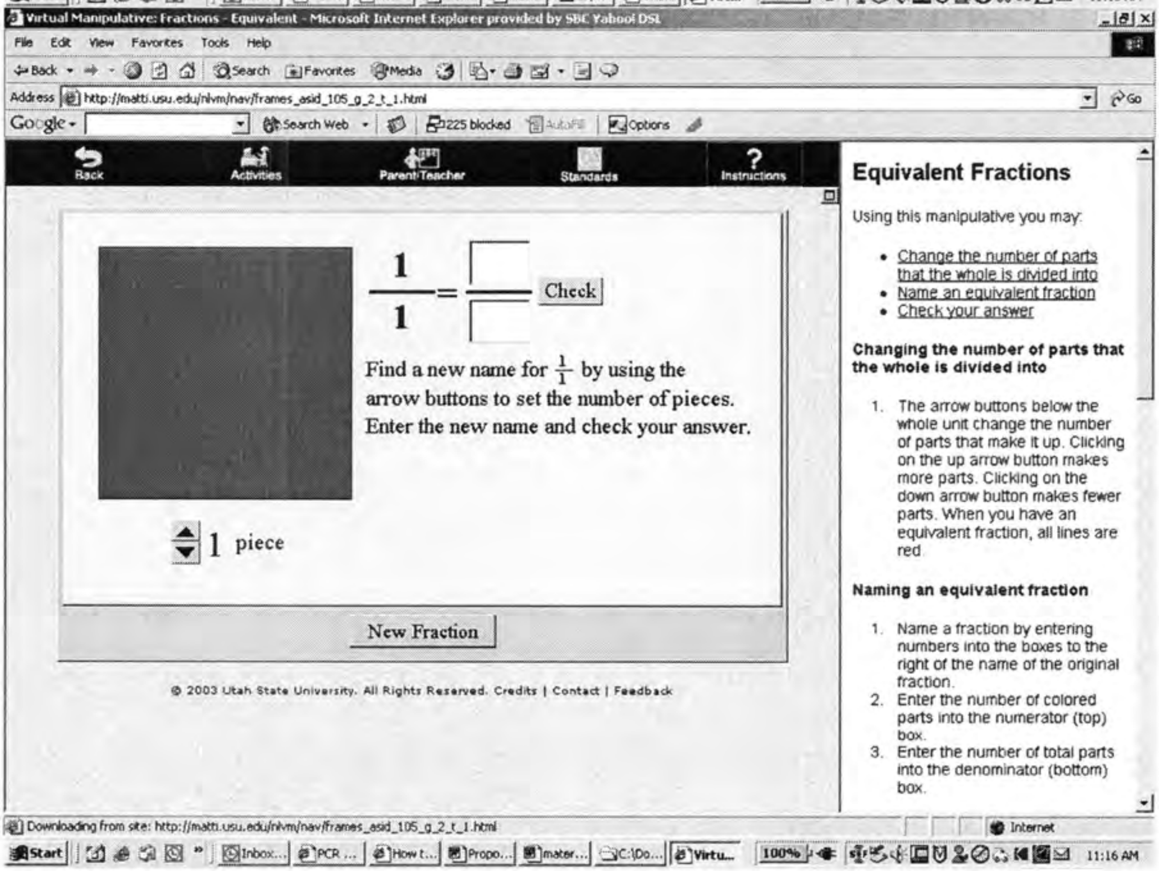
Adding Fractions
Using this manipulative you may:
Find a common denominator
Name equivalent fractions
Combine fraction representations
Write a fraction sum
Work another problem
Finding a common denominator
1. To find a common denominator, use the up and down arrow buttons located under each whole. The up arrow button increases the number of parts a whole is divided into. The down arrow key decreases the number of parts.
Naming equivalent fractions
1. Once a common denominator has been identified, type the names of the equivalent fractions into the appropriate boxes. Check your answer by clicking on the "Check" button. If you have specified a correct response, the interface will change.
Combining fraction
11:13 AM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Activities
Parent/Teacher
Standards
Instructions
1/1 =
Check
Find a new name for 1/1 by using the arrow buttons to set the number of pieces. Enter the new name and check your answer.
1 piece
New Fraction
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Equivalent Fractions
Using this manipulative you may:
Change the number of parts that the whole is divided into
Name an equivalent fraction
Check your answer
Changing the number of parts that the whole is divided into
1. The arrow buttons below the whole unit change the number of parts that make it up. Clicking on the up arrow button makes more parts. Clicking on the down arrow button makes fewer parts. When you have an equivalent fraction, all lines are red.
Naming an equivalent fraction
1. Name a fraction by entering numbers into the boxes to the right of the name of the original fraction.
2. Enter the number of colored parts into the numerator (top) box.
3. Enter the number of total parts into the denominator (bottom) box.
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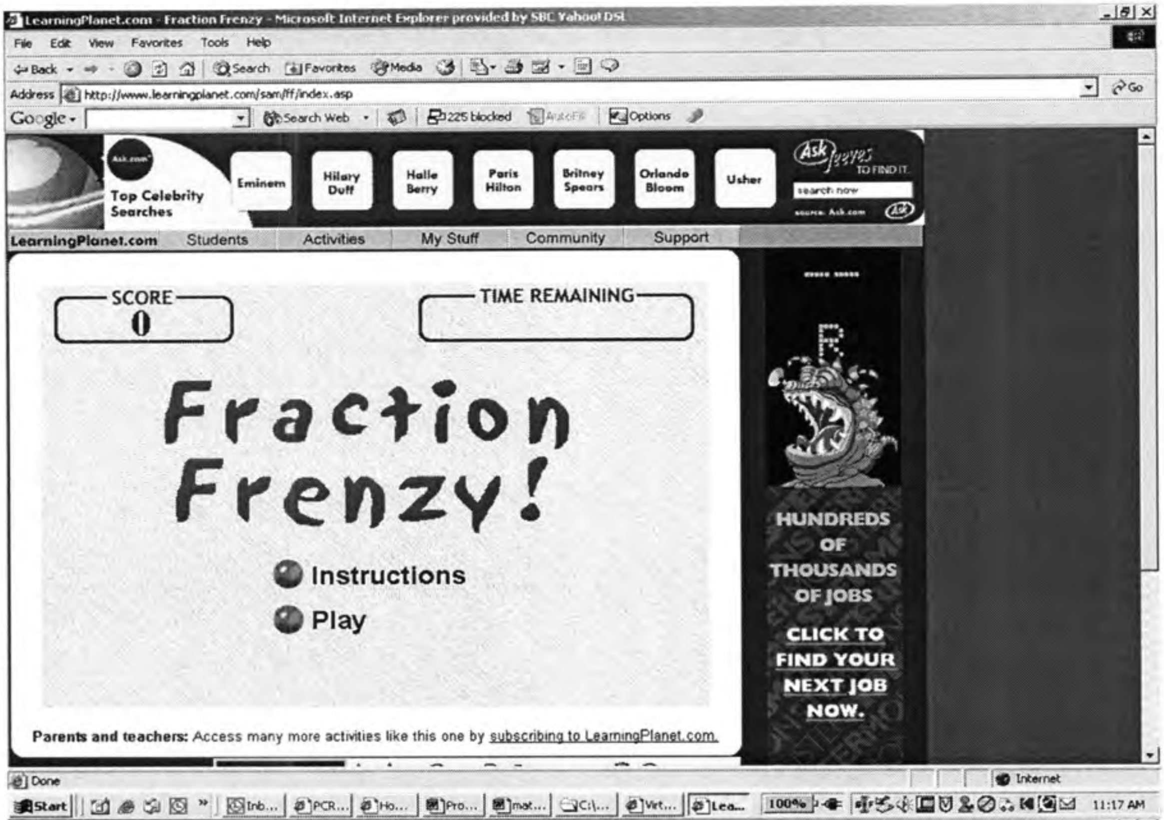
11:16 AM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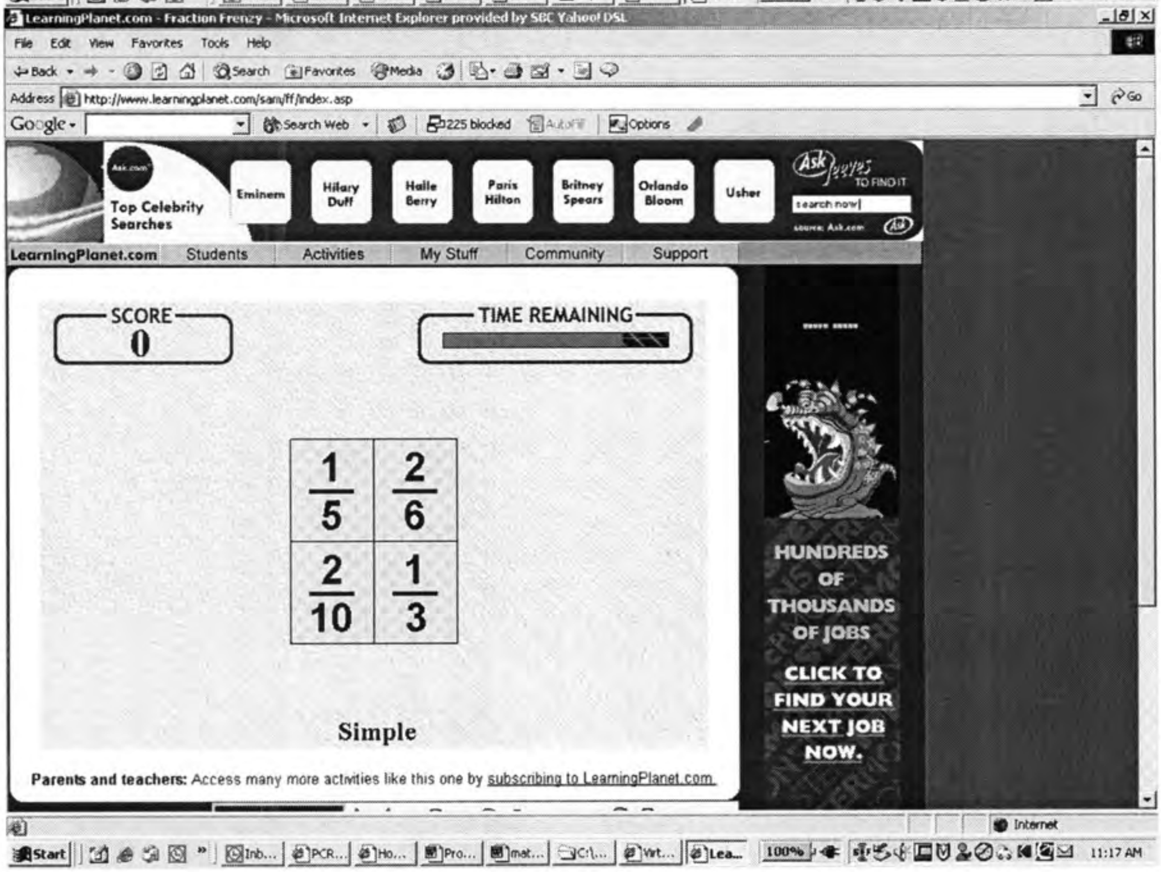
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SCORE
0
TIME REMAINING
1/5
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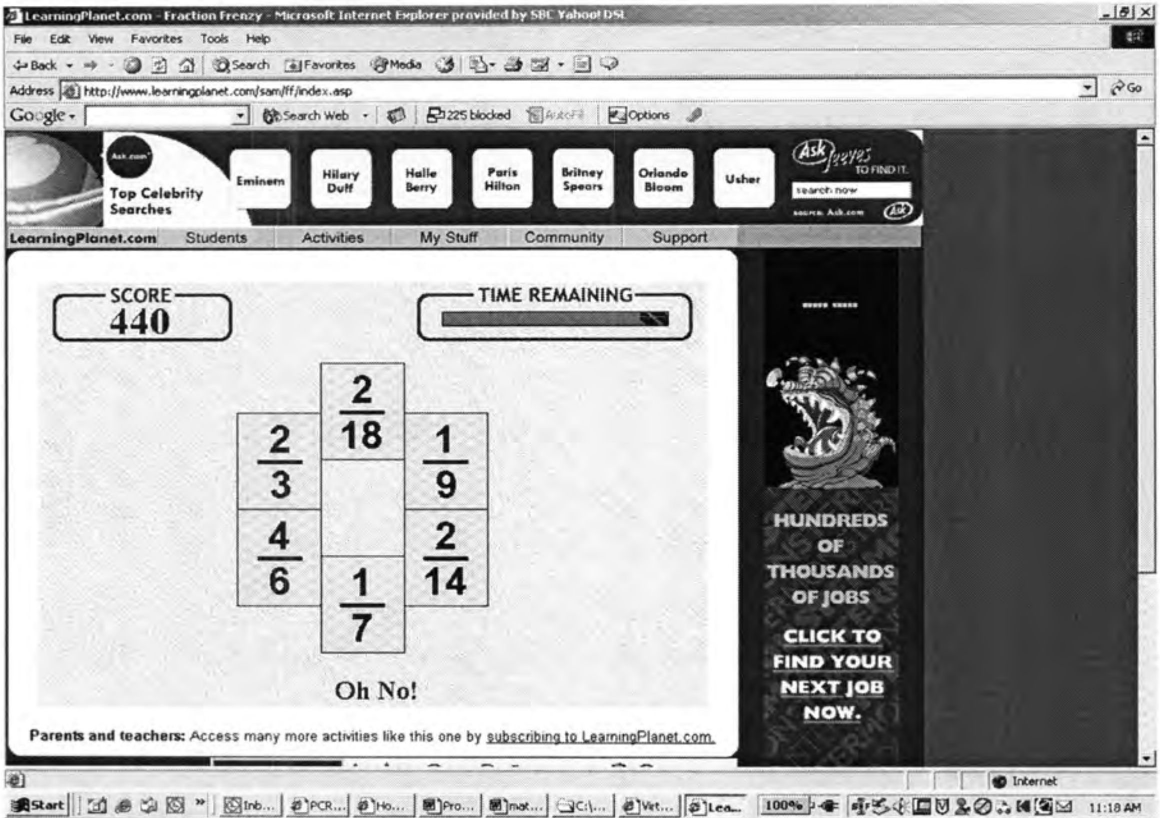
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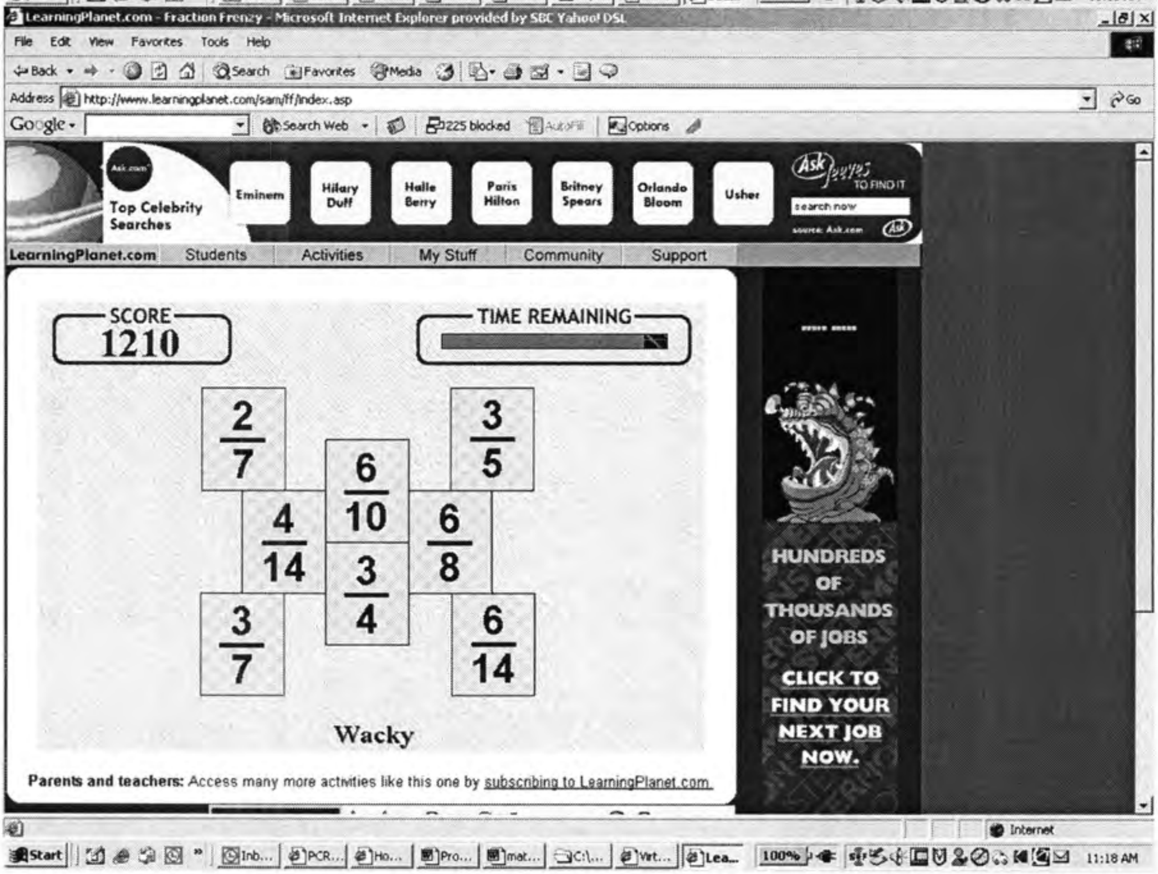
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