A QUASI-EXPERIMENTAL APPROACH TO DETERMINING THE EFFECT OF THE CONCEPT ATTAINMENT MODEL OF TEACHING ON SIXTH AND NINTH GRADE STUDENT ATTITUDES AND CONCEPT MASTERY

MASTER'S PROJECT

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DEDICATION

To My Beloved Family

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I. INTRODUCTION

Purpose for the Study

The primary purpose of this study was to determine the effectiveness of the concept attainment model of teaching in fostering student mastery by sixth and ninth grade students of the basic mathematics concept "prime number." The concept "prime number" is essential to the understanding of many mathematics and algebraic operations. Therefore, it is an important concept for students to master.

The second purpose of this study was to give the author the opportunity to determine whether both the content of "prime numbers" and the inductive thinking process skill can be taught concurrently using the concept attainment teaching model, which is within the information-processing family of teaching models. The Information Processing Family is a family of teaching methods that directly teaches both disciplinary content and the intellectual process. Further, some research suggests that this family of models is more effective than other teaching methods, and that this family removes the traditional dichotomies between teaching content and intellectual processes (Joyce & Weil,1992).

The third purpose of this study was to determine whether the attitudes of the sixth and ninth grade students toward the concept attainment model of teaching changed after having experienced a concept attainment model of teaching lesson on the concept "prime number." In teaching a previous sixth grade class, the author used the concept attainment model of teaching. All students enjoyed the variation in the teaching method used in class, and some enjoyed the problem solving that was required. However, some became frustrated when they could not solve the problem quickly and quit trying to solve the problem. The author was interested in measuring the change in attitude of students experiencing the concept attainment model of teaching.

One of the general curriculum objectives at the school where the researcher taught was to help students to reason logically and independently, and to develop an attitude of inquiry. One of the school's target goals, listed in its "Target Goal and Implementation Plans" was that students would increase critical thinking skills (Hopfengardner, 1993). Therefore, the fourth purpose for this study was to begin meeting these goals by using the concept attainment model of teaching; it is a model of teaching that requires the use of critical thinking by students. According to Joyce & Weil (1992), the core of good thinking is the ability to problem solve, and the essence of problem solving is the ability to learn in puzzling situations. Learning how to learn or think is what school is all about, and the concept attainment model of teaching is one model that teaches students to learn to think (Joyce & Weil, 1992).

The final purpose of this study was to apply the quasi-experimental approach to find out if this approach would be a useful and practical tool in determining whether a significant level of change in mastery level occurred as a result of the use of a model of teaching. If useful and practical, the author would build a database of statistical results comparing the effectiveness of different models of, or combination of models of, teaching for the same lesson concept.

Problem Statement

The objective of this study was to evaluate the effectiveness of the concept attainment of teaching on sixth and ninth grade student mastery of a mathematics concept and to determine the students' attitudes toward this teaching method.

Hypotheses

No significant difference exists between the pretest and posttest mean scores of sixth grade students who have been exposed to a mathematics concept lesson using the concept attainment model of teaching.

No significant difference exists between the pretest and posttest mean scores of ninth grade students who have been exposed to a mathematics concept lesson using the concept attainment model of teaching.

No significant difference exists between the pretest and posttest mean attitude scores toward the concept attainment model of teaching by sixth grade students after being taught a lesson which uses the concept attainment model of teaching.

No significant difference exists between the pretest and posttest mean attitude scores toward the concept attainment model of teaching by ninth grade students after being taught a lesson which uses the concept attainment model of teaching.

Assumptions

The author assumed that teaching methods influence student learning and attitudes. Secondly, the assumption was made that the quasi-experimental design will control for selection and mortality variables if the same students take the pretests and posttests. In addition, the author assumed the testing instruments are reliable in that they measure the attitudes and mathematics skills they are intended to measure. Finally, the assumption was made that students' responses to the semantic differential pretests and posttests would be genuine.

Limitations

The design of this experiment, T1 X T2 and T1 X T2, lent itself to limitations. First, contemporary history or environment may have affected the results. Students may have been exposed to the concept attainment model of teaching or the concept of "prime number" in another subject area, e.g., science or physics. Secondly, the natural process of maturation may have accounted for improvement of posttest mathematics skill or attitude scores. Thirdly, completion of the pretests may have served as a learning experience that caused students to change their responses on the posttests independently of the teaching treatment. Fourthly, statistical regression may have influenced the results of the ninth grade results in this project, because Algebra I was open only to those math students which passed the Algebra I placement test. Finally, a further limitation of this quasi-experimental approach was the absence of validity testing of the parallel forms of the pretests and posttests. The assumption is made that the pretest and posttest content accurately measures achievement of the mathematics concept "prime number." Also, the semantic differential pretests and posttests derived from Osgood's Factor Analyzed List (see Isaac and Michael, 1990) also has a limitation. "A principal limitation inherent in this or any other scale which depends on subjective judgement is interpretation; even though statistically significant differences between groups can be established, it is difficult to pin down either the theoretical or utilitarian meaning of this difference" (Isaac and Michael, 1990, p. 147). Thus, the author may have misinterpreted the semantic differential differences.

Definition of Terms

Attribute(s). This word stands for the characteristic(s) or feature(s) of examples (Joyce & Weil, 1992).

Attribute value. This is the degree to which an example displays an attribute.

Category. This is a data set or subset that shares one or more attributes (Joyce & Weil, 1992).

Concept attainment. Joyce states that this is an inductive learning process in which students are required to determine the attribute(s) of a concept already formed by the teacher. Joyce and Weil (1992) quote Bruner's definition to be "the search for and listing of attributes that can be used to distinguish exemplars from nonexemplars of various categories" (p.144).

Concrete Operational Stage. This is Piaget's term for that stage of cognitive development which occurs between the ages of six to twelve years and in which the student is capable of mentally reversing actions but can solve problems only by generalizing from concrete experiences (Biehler & Hudson, 1986).

Conjunctive Concepts. These are concepts defined by the presence of one or more attributes (Joyce & Weil, 1992).

Convergent Exemplars. Exemplars are convergent when irrelevant attributes of exemplars are as similar as possible (Tennyson, Woolley, and Merrill (1972).

Disjunctive Concepts. These are concepts defined by the presence of some attributes and the absence of others (Joyce & Weil, 1992).

Divergent Exemplars. These are concepts in which irrelevant attributes of exemplars are as different as possible (Tennyson, Woolley, and Merrill, 1972).

Effect Size. This is a statistic used to show the effect of a treatment. It is obtained by subtracting the average of the control group from the average of the experimental group and dividing the result by the standard deviation of the control group (Joyce & Weil, 1992). Effect size is not used in this quasi-experimental research project.

Essential Attribute(s). These are attribute(s) critical to a category of examples (Joyce & Weil, 1992).

Exemplars. These are a data set of positive and negative examples. The positive exemplars contain the essential or critical attributes of the concept. The negative exemplars are missing the essential or critical attributes exhibited by the positive exemplars (Joyce & Weil, 1992).

Finite Class. These are those concept attainment exemplar sets in which all the irrelevant attributes for a concept can be specified.

Formal Operational Stage. This is Piaget's term for that stage of cognitive development which occurs during adolescence in which the student is increasingly able to deal with abstractions, form hypotheses, solve problems systematically, and engage in mental manipulations (Biehler & Hudson, 1986).

Infinite Class. These are those concept attainment exemplar sets in which all the irrelevant attributes for a concept cannot be specified.

Matched Exemplars. Irrelevant attributes of exemplars and nonexemplars are as similar as possible (Tennyson, Woolley, and Merrill, 1972).

Misconception. This is the student classification behavior outcome in which the student identifies an example of a concept as an nonexample, and identifies a nonexample as an example (Tennyson, Woolley and Merrill, 1972).

Nonexemplars. These are nonexamples, i.e., examples which do not contain the attribute(s) of a category (Joyce & Weil, 1992).

Overgeneralization. This is the student classification behavior outcome in which the student correctly identifies the examples of a concept, but also classifies a nonexample as an example (Tennyson, Woolley and Merrill, 1972).

Rational Set . A rational set is comprised of a full range of teaching and testing examples that reflect the different levels of discrimination and generalization required for a student's mastery of a specific concept (Driscoll & Tessmer, 1985; Markle, 1975).

Rational Set Generator. A heuristic tool, the rational set generator was developed for writing a "rational set" and used extensively in Concept attainment research (Driscoll & Tessmer, 1985; Markle, 1975).

Undergeneralization. This is the student classification behavior outcome in which the student correctly identifies the more obvious examples of a concept, but classifies the less obvious, or more complex, example as a nonexample (Tennyson, Woolley and Merrill, 1972).

II. REVIEW OF THE RELATED LITERATURE

Introduction

The genesis of this thesis project was the University of Dayton's Models of Teaching course, EDT 500, in which the concept attainment model of teaching, among other excellent and powerful teaching models, was introduced. The concept attainment model of teaching intrigued the author because it is effective for teaching concepts inductively across the curriculum and is especially effective in teaching higher level, abstract concepts (Eggen and Kauchak, 1988). Its purpose is not just to teach concepts inductively, but to teach metacognition relative to inductive thinking, i.e., bring students to think about thinking inductively (Joyce and Weil, 1992).

The models of teaching approach assumes that no one teaching approach is superior to all others across differing learning outcomes (Wheeler, 1978). Concept attainment is one model used in the models of teaching approach and has to be used with a combination of models to be effective, even when teaching high order thinking (Joyce & Weil, 1992; Eggen and Kauchak, 1988). Indeed, the teacher has to match the model with the teaching goal and the subject matter, using a variety of models to motivate students (Marzano, 1983; Moeschl & Costello, 1988; and Hall, 1990).

When the author used the concept model of teaching to teach math and English concepts in her classroom for a course project, she found the students were motivated and challenged by the inductive lessons. However, the author felt she needed to study the model in more depth to use it most effectively in bringing students to concept mastery. This thesis project gave the author the opportunity to do so using a quasi-experimental, scientific process that could be built on as the model was used in the classroom.

Advantages of the Concept Attainment Model

The concept attainment model has many advantages. First, the model empowers teachers with a strategy that enables students to learn to apply inductive problem solving strategies to educational content in a discovery mode, as suggested by Piaget (Joyce and Weil, 1992). Second, students use metacognition when provided with a concept attainment lesson, i.e., a level in which they are able to think about thinking (Joyce and Weil, 1992). Third, the use of the concept attainment model results in students' having learned a powerful inductive learning process useable in all their studies (Joyce and Weil, 1992). Fourth, the concept attainment model is extremely effective in evaluating student concept mastery (Joyce and Weil, 1992). The teacher can quickly determine whether a student has mastered a concept whether during pretest, lesson, or posttest evaluation. Further, if a student falls short of mastery, the evaluator can quickly determine where the student is in regard to the concept. The teacher can conclude whether the student has missed an essential characteristic (under-generalization), applied irrelevant characteristics to the concept (overgeneralization), or both (misconception) (Tennyson, Woolley and Merrill, 1972). Fifth, the model is applicable at all grade levels at any place during a unit of study. That is, the model can be used to introduce or expand unit of study lessons (Joyce and Weil, 1992). Joyce suggests a social studies teacher use a series of concept attainment lessons to teach important or controversial concepts. Each concept attainment lesson would provide the student with a different perspective for controversial concepts which would lead the student to an "awareness of alternative perspectives" (Joyce and Weil, 1992).

Sixth, research shows the use of the concept attainment model results in an increase in "effect size," although small, between students learning through concept attainment and those learning via the traditional lecture method for the lower-order outcomes (the concept information gained and retained). A larger differential of "effect size" results for the higher-order outcome of concept formation when the concept attainment model is combined with other models of teaching, such as another information processing family model, the advance organizer model, and the cooperative learning model, a member of the social family (Joyce and Weil, 1992). In one study see Joyce and Weil, 1992), a cooperative and inductive activity was combined with the concept attainment approach. The lowest scorer in the experimental group that received the combined model class scored higher than the highest scorer in the control group. Thus the experimental group members reached a higher level of concept "attainment" than the control group members.

The seventh advantage of the concept attainment model is that it is a model that is highly appropriate in a culturally diverse classroom: "Because the concept attainment model utilizes relational processes to teach concepts, it plays to the cognitive strengths of many Native, African and Hispanic Americans as well as to cross-cultural and female students" (Lasley and Matczynski, 1997, p.115).

Disadvantages of the Concept Attainment Model

A first disadvantage is that the concept attainment model of teaching is new to most teachers. Teachers have little experience and training with the concept attainment model of teaching, in general, and especially with the use of the nonexamples the concept attainment model of teaching requires. In their own schooling and teacher education and training programs, teachers have been immersed in teaching that presents and models the use of examples. The "use of nonexamples is a relatively complex skill that requires coaching and an in-depth knowledge of subject matter" (Lasley and Williams,1990, p.48). However, today's teacher education and training programs do not yet provide teachers with the "substantial guided practice and training" required for teachers to be ready to use the concept attainment of teaching in their classrooms (Lasley and Williams, 1990). This means teachers have to gain this knowledge and experience primarily through their own initiative.

A second disadvantage is the time and effort required to develop concept attainment lesson materials. Textbook publishers of collegiate and elementary and secondary textbooks do not yet present, explain, or highlight teaching using the concept attainment model of teaching, or other inductive models (Lasley and Williams, 1990). Thus, teachers have to develop their own materials using models of teaching textbooks and research literature addressing the concept attainment model as reference. In addition, there is a complexity involved in developing a "rational set" of examples and nonexamples for use in the lessons. Thus the teacher has to take additional time and effort to develop techniques in the design and development of these instructional materials for a concept attainment lesson (Joyce & Weil,1992; Eggen and Kauchak, 1988; Driscoll & Tessmer,1985). On the surface, the concept attainment model seems straightforward and easy to implement. While this may be true for simple, concrete concepts taught in isolation, review of research reveals nuances and particulars to be understood and addressed before an effective lesson, or lesson sets, can be developed for high level, abstract concepts, especially when addressing the system of coordinate and superordinate concepts of which a concept is a part. While the EDT 500 course text, Models of Teaching (Joyce & Weil,1992), was useful as an overview and first step in understanding the concept attainment model, the author recommends that teachers review the literature in order to better understand how to build effective concept attainment lessons and formative evaluations. This is because the research literature contains definitions and relationships not addressed in any one book or article which are crucial in understanding how to build effective exemplar sets to use in lessons and testing. The author found the textbooks Strategies for Teachers (Eggen and Kauchak, 1988), Models of Teaching (Joyce and Weil, 1992), Strategies for Teaching in a Diverse Society (Lasley and Matczynski, 1997), and the article by Tennyson, Woolley, and Merrill (1972) to be invaluable in learning the concept attainment language and how to develop concept attainment lesson plans and formative evaluations.

A third disadvantage is the class-time lessons take when using concept attainment. Time becomes critical in a concept attainment lesson even for the simpler concepts. In one research experiment (see Trempe, 1992), the same mathematical concept taught using both the concept attainment model and the lecture approach, took twenty minutes and eight minutes, respectively. One way to reduce time in language lessons is to underline the primary word (Joyce and Weil, 1992). For example, when presenting a lesson on direct objects, it's very useful, and really necessary, to underline the direct objects in the sentences for the concept examples (positive exemplars) and the same word, not used as a direct object, in the negative examples (nonexemplars). This allows the student to focus immediately on the important aspect of the sentence. If the word is not underlined, the task is made more complex, i.e., the student must look at the complete sentence and determine the focus, and more time is unnecessarily consumed because of the complexity presented.

A fourth disadvantage is the preparation time required of the teacher to include the additional teaching competencies that have to be added to the concept attainment model by the teacher in order for it to be used effectively in the classroom (Joyce & Weil, 1992; Eggen and Kauchak, 1988; Wheeler, 1978). The competencies needed to teach using the synectics, inquiry, Taba-model, and concept attainment models of teaching were addressed by one study (Wheeler, 1978). Teaching competencies were derived for these four models of teaching and the competency sets were cross-matched with a generic skills list generated by two studies, "The Essential Competency Study" (State of Florida, 1975) and "A Validation of Self-Evaluation Procedures for Identifying Instructional Needs of Teacher Centers" (Carey, 1976). Concept attainment was found to be seventy-five percent congruent with the competencies. The study indicated that teachers would have to add additional components to those provided by the model. Some of these are reporting progress to peers and parents, the technical aspects of diagnosis, prescription, and evaluation, and the techniques involved in the design and development of instructional materials.

A fifth disadvantage is related to the specialization of the concept attainment model. It cannot be used to teach generalizations, facts, or explanations. It is an appropriate model to use primarily when the goal is learning a significant concept (Eggen and Kauchak, 1988; Joyce and Weil, 1992; Lasley and Matczynski, 1997).

A sixth disadvantage of the model is that it is an appropriate model to teach a concept only if the concept to be taught has clear, definable attributes (Joyce & Weil, 1992). For example the concept attainment model is not appropriate for lessons dealing with artistic style (Bengston, Scholler, & Cohen, 1978). Artistic style may not have the clear, definable attributes required to be a candidate for the concept attainment model. This review of relevant literature did not find any one book or article that addressed a set of concepts that should be or should not be taught using the concept attainment model, either alone or in combination with other models of teaching. Neither did the author find a concept attainment lesson plan resource book. Therefore, teachers have to be able to recognize when the concept model of teaching is the model of choice for a lesson concept and then create their own lesson plans, lesson materials, and summative and formative evaluations.

The Teaching Process

While each model of teaching has its own defining syntax and description, all have to be integrated into the teaching process of preparing lesson plans and materials, class presentation, and summative and formative evaluations. The concept attainment model of teaching is described in Table 1, which shows alignment of Eggen and Kauchak's concept attainment model hierarchy, Joyce and Weil's social system and syntax, and Lasley and Matczynski's phases. Joyce and Weil 's syntax and Lasley and Matczynski's phase II are listed twice because they overlap Eggen and Kauchak's steps. These steps are required to integrate the concept attainment model into the teaching process.

Table 1: AUTHOR'S CONCEPT ATTAINMENT MODEL COMPARISON CHART

(Syntax, Phases, and Variations)

Eggen	Joyce	Lasley
Planning for Concept Attainment Activities	Social System	Phase One: Concept Identification Phase Two: Exemplar Identification:
Implementing Concept Attainment Activities	Syntax	Phase Two: Exemplar Identification Phase Three: Hypothesizing Phase Four: Closure Phase Five: Application
Evaluating Concept Attainment Activities.	None	Evaluation Criteria
Variations in Concept Attainment Activities	Social System	Instructional Variations

Notice that there are variations in the concept attainment model. The literature primarily addresses C.A.I, the primary concept attainment model. The other models, C.A.II and C.A.III, will be addressed briefly later in this paper.

Planning Concept Attainment Activities

Goal and Concept Identification

Eggen and Kauchak's first step in planning concept attainment activities is to identify the lesson goal. If the goal is to teach a concept in a process-oriented manner, then the concept attainment model is a model of choice. If the lesson goal is to teach a fact, generalization, or explanation, then the concept attainment model is not an appropriate choice (Eggen and Kauchak, 1988). Lasley requires the concept to be significant. All three authors require the concept to have clear and distinguishable attributes and all list "prime number" as an example of a concept for which the concept attainment model is appropriate.

Concept Types

Concepts can be conjunctive, disjunctive, or connective (Joyce & Weil, 1992). Whereas a conjunctive concept is defined by the presence of one or more attributes, a disjunctive concept is not only defined by the presence of one or more attributes, but also by the absence of one or more attributes. Joyce defines "prime number" as a disjunctive concept because it defined "by the absence of a factor other than one and the number itself" (Joyce & Weil, p.150). Connective concepts, a name coined by the author, are defined as "concepts that require a connection between the exemplar and some other entity" (Joyce & Weil, p.150). Joyce identifies the concept parasite with the entity host.

Selection of Exemplars

In Eggen and Kauchak's second planning step, teachers select positive exemplars, negative exemplars, and determine the number of exemplars to be used in the lesson (Eggen and Kauchak, 1988). Joyce and Weil and Lasley and Matczynski suggest 20 example pairs and 8-10 examples, respectively. Eggen and Kauchak state the number of exemplars depends on the concept; however, the exemplar sets in his book ranged from 5-11 examples. Table 2 shows the exemplars Eggen and Kauchak chose for a concept attainment lesson on the concept "prime number" (Eggen and Kauchak,1988).

Table 2: PRIME NUMBER EXEMPLAR SET

1. 3-Yes	7. 11-Yes
2. 4-No	8. 13-Yes
3. 5-Yes	9. 15-No
4. 7-Yes	10. 17-Yes
5. 6-No	11. 21-No
6. 9-No	

Source: Adapted from Eggen, P.D., & Kauchak, D.P. (1988). Strategies for Teachers. Englewood Cliffs, N.J.: Prentice Hall, p. 157.

The exemplar is one of the two most critical parts of the concept attainment model; the other is the concept attribute (Joyce & Weil, 1992). Exemplars are a data set of examples and nonexamples of a concept used by the teacher to represent a concept for students. While a definition describes the critical attributes of a concept, a positive exemplar exhibits those critical attributes. Concept attainment positive exemplars strengthen critical or essential attribute relationships in a student's mind and function to assess the generalization range of the student (Driscoll and Tessmer, 1985; Markle and Tiemann,1969). Positive exemplars are also called "examples" and "yes," and are often represented by a smiley face in elementary school lessons.

Negative exemplars are used to allow the student to de-emphasize irrelevant attribute relationships and function to assess the student's discrimination ability. Thus a student's mastery is tested by the student's ability to classify concept examples; but classifying examples is reflective of the student's ability to both generalize using examples and discriminate using nonexamples (Driscoll and Tessmer, 1985; Markle and Tiemann,1969). Negative exemplars are also called "nonexamples" and "no," and are often represented by a sad face in elementary school lessons.

The numbers "3" and "4" are positive and negative exemplars, respectively, of an exemplar data set for the concept "prime number." Attributes are the characteristics displayed by exemplars. A critical or essential attribute is a characteristic that has to be exhibited by an exemplar to make it positive or representative of the set. An attribute or characteristic displayed by an exemplar that is not critical or essential is known as an irrelevant attribute. The critical attribute for the number "3", for the concept "prime number", is that the number "3" has only two factors, itself and 1. The number "3" also has the attribute that it is an odd number, but that attribute is irrelevant to the concept "prime number", and is therefore an irrelevant attribute for the concept "prime number." Joyce and Weil and Lasley and Matczynski also address the exemplar's attribute value, which is the extent that the attribute is present in an example (Joyce and Weil, 1992; Lasley and Matczynski, 1997). The number "3" fully represents the "prime number" concept attribute of having only two factors, itself and 1. The number "4" is a nonexemplar because it has three factors,"1," "2," and itself. It also has the attribute that it is an even number, which is an irrelevant attribute for the concept "prime number."

Example and Nonexample Effectiveness

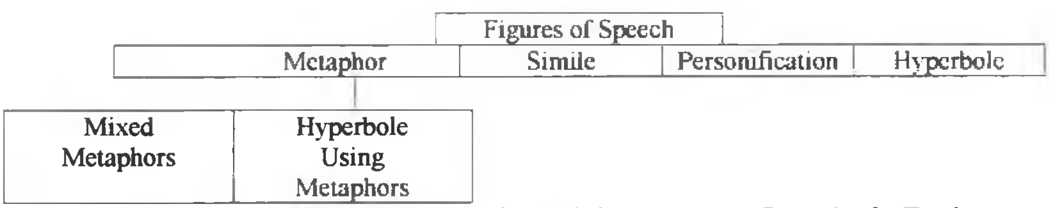
Selection of appropriate examples and nonexamples is critical to the mode's effectiveness in teaching concepts (Joyce & Weil, 1992; Eggen and Kauchak, 1988; Driscoll & Tessmer, 1985). Providing examples and nonexamples of a concept is most effective if the examples vary widely in irrelevant attributes, while nonexamples differ from the examples in (if possible) one attribute at a time (Markle & Tiemann, 1969; Tennyson, Woolley, and Merrill, 1972). The positive number "2" is the only "prime number" that has the irrelevant attribute of even number. All other "prime numbers" have the irrelevant attribute of odd number. In the author's opinion, every exemplar data set for a concept attainment lesson on the concept "prime number" should contain the number "2" to insure students fully realize there is one even number that is a "prime number."

Examples and nonexamples are most effective, i.e., likely to result in being correctly classified by students if they are matched and divergent, i.e., the irrelevant attributes are as different as possible (Tennyson, Woolley & Merrill, 1972). Exemplar pairing of positive and negative examples is at the center of the C.A.I model. Matching is pairing the exemplars so the irrelevant attributes are as similar as possible. All the yeses and noes in Eggen and Kauchak's exemplar set are odd numbers, an irrelevant attribute. It might be said the exemplars were matched on the irrelevant attribute, odd number. The number "2" provides the divergence that will lead students to distinguish "odd" and "even" as irrelevant attributes of the "prime number" concept.

Exemplar Set Creation Tools

The concept analysis (Eggen and Kauchak, 1988; Peters, 1974) and the rational set generator (Driscoll & Tessmer, 1985; Markle,1975) are tools used to help insure an exemplar set contains a representative set of concept examples. In a concept analysis, the teacher looks at related concepts to find the negative exemplars for a lesson. While optional for Eggen and Kauchak, the concept analysis is required and is what sets apart the Frayer concept attainment model from Eggen and Kauchak's (Eggen and Kauchak, 1992; Peters, 1974). Figure 1 shows the related concepts for a concept attainment lesson on metaphors, a figure of speech, used by Eggen and Kauchak (Eggen and Kauchak,1988).

Figure 1: Figures of Speech



Source: Adapted from Eggen, P.D.. & Kauchak, D.P. (1988). Strategies for Teachers. Englewood Cliffs. N.J.: Prentice Hall, p.151.

The Rational Set Generator (see appendix A) is a heuristic tool for writing a full range of teaching and testing examples that reflect the different levels of discrimination and generalization required for a student's mastery of a specific concept. The Rational Set Generator procedure was used to produce a physics matrix (see Appendix A) that was effective in assessing student mastery of physics concepts (Driscoll & Tessmer, 1985; Markle, 1975). The Rational Set Generator can be used by teachers to build exemplar sets that are not fully rational sets, i.e., fully rational sets are not required for the matrix to be useful (Driscoll & Tessmer, 1985). It's the author's opinion that the rational set generator should only be used by a teacher experienced in building exemplar sets because of its complexity and the lack of literature fully addressing its use.

Exemplars Sequencing

Exemplar sequencing is critical to the success of a concept attainment lesson. The rule is to place the most obvious examples first for quick pattern recognition and concept attainment. Place the less obvious examples first for slower pattern recognition and concept attainment. This causes the students to spend more time on practicing their inductive process skills (Eggen and Kauchak, 1988; Joyce and Weil, 1992). The teacher chooses the exemplar data set order based on the sequence of attributes the teacher wants the students to address and on the order of the hypotheses the teacher wants to lead the students.

Selecting the Exemplar Presentation Medium

Eggen and Kauchak (1988) specifically address the medium to use for a concept attainment lesson. Select the medium that illustrates as many of the concept attributes as possible. Actual objects make the best exemplars. Other medium choices are pictures, words, diagrams, recordings, and tapes. Pictures generally illustrate concepts more effectively than words. Media other than words should be used for nonreaders. Words are a choice for good readers (Eggen and Kauchak, 1988).

Implementing Concept Attainment Activities

The table in APPENDIX R provides a comparison of Eggen and Kauchak (1988), Joyce and Weil (1992), and Lasley and Matczynski (1997), C.A.I lesson syntax. The classic lesson begins with the teacher stating that he/she has a concept or category in mind that the students need to identify. The teacher then writes one of the following headings on the chalkboard or on chart paper.

Table 3: EXEMPLAR LABELS

PositiveExemplar	**Negative Exemplar**
Example	**Nonexample**
Yes	**No**
Smiley Face	**Sad Face**

Then, the teacher writes the first positive and negative exemplars under the appropriate heading and an iterative process begins. The teacher asks the students to hypothesize the concept or category the teacher has in mind. Students generate hypotheses. The teacher displays the next exemplar pair from the prepared exemplar set to provide more attribute information. Students refine their hypotheses, keeping some and rejecting others. The teacher keeps presenting exemplar pairs, allowing hypotheses validation and invalidation, until all exemplar pairs that are crucial for the total concept formation are presented and the students have correctly identified all valid hypotheses and invalidated all incorrect hypotheses.

Next the teacher provides nonlabeled exemplars and asks the students to identify them as examples or nonexamples of the concept. When the students are correctly applying the essential attributes in identifying the examples and nonexamples, the teacher names the concept and provides the students with a concept definition that begins with the concept label and uses the concept's essential attributes as the definition. For example, a "prime number" is a number that has only two factors, itself and 1. The teacher then reviews and demonstrates why the concept attributes define whether an exemplar is a positive or negative example.

Students are then asked to generate their own examples and nonexamples. The teacher uses these examples to more fully explore the differences between relevant and irrelevant attributes.

Only Joyce and Weil (1992), have a phase addressing the analysis of thinking strategies. This phase is the metacognition phase, i.e., where the students discuss their thoughts during the lesson, the role of the hypotheses and attributes, and the type and number of hypotheses. The goal is for students to recognize the strategies they are using and when a particular strategy is appropriate (Joyce and Weil, 1992).

Evaluating Concept Attainment Activities

Eggen and Kauchak (1988) address the testing of the students and states students should be asked to do one or more of the following for evaluation.

1. Select examples from a list of exemplars.
2. Provide additional examples of the concept.
3. Identify concept attributes.
4. Give a concept definition.
5. Identify the definition from a list of definitions.
6. Identify coordinate, superordinate, or subordinate concepts, or some combination thereof.

Lasley and Matczynski, (1997) provide a useful number of questions under the heading "evaluation criteria" that a teacher should ask after the lesson to determine whether a lesson was "properly developed and sequenced." This is because "…teachers who first use the concept attainment strategy will struggle to make certain they include all the phases of the lesson" (p.118). The teacher could also use the questions when developing the lesson plan to help insure its proper development.

Student Classification Behavior Outcomes

Another research study explained that there are four possible student classification behavior outcomes in concept attainment assessment (Tennyson, Woolley & Merrill, 1972). The student can correctly classify the non-labeled exemplars, exhibiting correct classification behavior. The other three outcomes reflect one of the following classification errors: overgeneralization, undergeneralization, or misconception. Overgeneralization means that in addition to identifying all the class member examples correctly, the student selects some nonexemplars as class members. The student "fails to discriminate between classes" (Tennyson, Woolley and Merrill, p. 145). Undergeneralization pertains to the instance when the student correctly classifies the simpler class member examples, but identifies the more complex exemplars as nonexemplars. The student "fails to generalize to all members of the class" (Tennyson, Woolley and Merrill, p. 145). Finally, misconception reflects the case in which the student has identified some irrelevant attribute, or combination of irrelevant attributes, as relevant. The result is that examples not having the irrelevant attribute are classified as nonexamples, and nonexamples having the irrelevant attribute are classified as examples (Tennyson, Woolley and Merrill, 1972). The teacher uses this assessment to determine what reteaching, if any, is necessary, and as input in the teacher's evaluation of the lesson effectiveness.

Concept Attained

Concept attainment is "the search for and listing of attributes that can be used to distinguish exemplars from nonexemplars of various categories" (Bruner, Goodnow, and Austin, 1967, p.233). "Concept attainment requires a student to figure out the attributes of a category that is already formed in another person's mind by comparing and contrasting examples (called exemplars) that contain the characteristics (called attributes) of the concept with examples that do not contain those attributes"(Joyce & Weil, 1992,p.144). But, when can the teacher say that a student has attained the concept? To Eggen and Kauchak, it is when the student can identify the concept's attributes (Eggen and Kauchak, 1988). To Joyce and Weil, it's when the student can correctly identify labeled examples and generate their own examples (Joyce and Weil, 1992). For Lasley and Matczynski, it's when students can create their own exemplars and describe each exemplar's critical attributes (Lasley and Matczynski, 1997). And for Frayer (see Peters, 1974), the student has to:

"1). Recognize an appropriate definition of the concept, 2). Distinguish between relevant and irrelevant attributes,

3). Identify examples and non-examples of a concept, and

4). Recognize relationships between related concepts"(p. 93).

Concept Attainment Model Variations

The classic concept attainment model is known as C.A.I., and is the model used for the quasi-experiment for this thesis project. It is Eggen and Kauchak's (1988) Concept Attainment Model I, Reception. This classic model is also Frayer's model of concept attainment (see Peters, 1974), the concept attainment model addressed in Models of Teaching (Joyce and Weil, 1992), and the primary model addressed in Strategies for Teaching in a Diverse Society (Lasley and Matczynski, 1997). Most research focuses on this model of teaching.

Eggen and Kauchak (1988) describe two additional concept attainment models: C.A. II, The Selection Strategy (II), and C.A. III, The Students as an Active Investigator (III). Lasley and Matczynski address C.A. II. The author recommends the reader review these two sources for examples of the respective concept attainment lesson. Joyce and Weil (1992) make only parenthetical reference to the other models. In the model's social system syntax section, Joyce and Weil state "...other concept attainment models are lower in structure"(p.158). No research was found which focused totally on one of the other models. Only one study (Louvert, 1988) was found that addressed the other models. Louvert (1988) refers to all three of Eggen and Kauchak's models, the context being foreign language lessons.

Figure 2: A Comparison of Concept Attainment I, II, and III

	Number of examples provided initially	Who determines next exemplar	Type of concept learning activity
C.A. I	Only first two labeled	Teacher	Reception
C.A. II	All, with first two labeled	Students	Selection (students choose from pool that teacher creates.
C.A. III	Only first two labeled	Students	Selection (students select their own exemplars)

Source: Adapted from Eggen, P.D., & Kauchak, D.P. (1988). Strategies for Teachers. Englewood Cliffs, N.J.: Prentice Hall, p. 181.

As can be seen, the teacher has the most control of the concept attainment lesson in C.A.I. The teacher provides all the exemplars in the order the teacher chooses. The student responds to the exemplars. Eggen and Kauchak (1988) see this as being the least demanding on the students and the teacher having the most control. In C.A. II, the teacher provides all the exemplars at once and labels the first two exemplars. The students choose the next exemplar to address from the provided list of exemplars. The teacher controls the exemplar list, but does not control the sequence in which they are addressed. Eggen and Kauchak (1998) see the students choosing the exemplar order as being more demanding on them and placing them in the position of having more autonomy. In C.A. III, the teacher provides the first two labeled exemplars, but no more. The students must provide all other exemplars. The teacher does not have control of the selection of exemplars. Eggen and Kauchak (1988) see this as the most demanding on the students and placing the students in the position of having the most autonomy.

Figure 3: Learner Autonomy and Demand Chart

Increasing Learner Autonomy

--------------------------------→

CAI CAII CAIII

--------------------------------→

Increased Demands on Learner

Source: Adapted from Eggen, P.D., & Kauchak, D.P. (1988). Strategies for Teachers. Englewood Cliffs, N.J.: Prentice Hall, p.181.

Review of the Related Literature Summary

Concept Attainment, a member of the information Processing Family of teaching models, is an inductive approach to teaching concepts, which is one model of choice when teaching significant concepts in a scientific or disciplinary manner. Although the concept attainment model of teaching is relatively new, there exists a good body of literature concerning it. The information available provides a generally objective look at the advantages, disadvantages, usefulness and effectiveness of the model.

Discussion regarding the advantages of using the concept attainment model of teaching addresses such disparate issues as the empowerment of teachers at various grade levels and subject areas with effective strategies for helping and evaluating students to the model's efficacy for different cultural groups.

Disadvantages of the concept attainment model of teaching in particular circumstances are also delineated. These include the "newness" of the teaching model, which means most teachers must take more time and effort as they are still unfamiliar with it and textbooks are not oriented to it, as well as the usefulness of the model in particular subject areas and concept specificity (see in particular, Eggen and Kauchak 1988; Joyce & Weil, 1992; Lasley & Matczynski, 1997).

Finally, no single work contains all the information essential for effective implementation and use of the concept attainment model of teaching. The teacher should draw upon several works in order to be aware of the best model strategies to use in planning activities, matching and sequencing exemplar sets, implementing lessons, and evaluating student tests.

III. PROCEDURE

Subjects

The subjects were 28 students taking sixth grade mathematics and 26 ninth grade students taking Algebra I. The sixth grade students were a heterogeneous group. Therefore, a full range of skill, motivation levels, and attitudes toward math should have been reflected. The ninth graders in Algebra I were selected using an Algebra I placement test. Therefore, these students were expected to be high achievers, excellent students, and highly motivated.

Setting

School. The school where this study was conducted was a private Kindergarten through twelfth grade parochial school. Approximately 350 students attend this school annually.

Community. This study was conducted in a small city in South Western Ohio near Dayton, Ohio. Members of this community are oriented primarily toward the medical or other professional occupations.

Construction of the Sixth Grade Mathematics Skill Test. The pretest and posttest were parallel forms of a mathematics skill test on knowledge of the mathematics concept "prime number", its attributes, examples and definition. Each form consisted of approximately 10 questions addressing the definition, attributes, and recognition of examples of the concept "prime numbers." Questions were developed from existing mathematics tests and materials. Selected teachers reviewed the mathematics pretest. The final form of mathematics skill test was prepared according to the recommendations of those teachers. The pretest and posttest are included in the appendices.

Construction of the Ninth Grade Algebra I Skill Test. The pretest and posttest were parallel forms of a mathematics skill test on knowledge of the mathematics concept "prime number", its attributes, examples and definition. Each form consisted of approximately 10 questions addressing the definition, attributes, and recognition of examples of the concept "prime number." Questions were developed from existing mathematics tests and materials. Selected teachers reviewed the mathematics pretest. The final form of mathematics skill test was prepared according to the recommendations of those teachers. The pretest and posttest are included in the appendices.

Construction of the Sixth Grade Semantic Differential. The pretest and posttest were parallel forms of a semantic differential on attitudes toward the Concept attainment lesson. Each form consisted of 19 polar adjective pairs derived from the literature. Osgood's factor analyzed list was used when organizing the semantic differential designed to measure the students' attitude toward the concept attainment approach to learning (Isaac & Michael, 1990). Selected teachers reviewed the pretest of the semantic differential. The final form of the semantic differential was prepared according to the recommendations of those teachers. The pretest and posttest are included in the appendices.

Construction of the Ninth Grade Semantic Differential. The pretest and posttest were parallel forms of a semantic differential on attitudes toward the Concept attainment lesson. Each form consisted of 19 polar adjective pairs derived from the literature. Osgood's factor analyzed list was used when organizing the semantic differential designed to measure the students' attitude toward the concept attainment approach to learning (Issac & Michael, 1990). Selected mathematics teachers reviewed the pretest of the semantic differential. The final form of the semantic differential was prepared according to the recommendations of those teachers. The pretest and posttest are included in the appendices.

Administration of the Sixth Grade Mathematics Skill Test. The author administered the finalized form of the sixth grade mathematics skill pretest in winter 1996. Five days after the concept attainment lesson was given, the author administered the posttest, a parallel form of the Sixth Grade Mathematics Skill Pretest. Three weeks after the posttest, the author administered a second posttest, a parallel form of the Sixth

Grade Mathematics Skill Pretest.

Administration of the Ninth Grade Algebra I Skill Test. The author administered the finalized form of the ninth grade Algebra I skill pretest in spring, 1995. Two days after the concept attainment lesson was given, the author administered the posttest, a parallel form of the Algebra I Skill Pretest.

Administration of the Sixth Grade Mathematics Semantic Differential. The author administered the finalized form of the sixth grade semantic differential pretest in winter 1996, prior to the mathematics skill pretest and concept attainment lesson. The day after the concept attainment lesson, the author administered the semantic differential posttest, a parallel form of the semantic differential pretest.

Administration of the Ninth Grade Algebraic Semantic Differential. The author administered the finalized form of the ninth grade semantic differential pretest in spring 1995, prior to the algebraic skill pretest and concept attainment lesson. Two days after the concept attainment lesson was given, the author administered the semantic differential posttest, a parallel form of the semantic differential pretest.

Design

Design to Test the First Hypothesis. The design for testing the first hypothesis regarding retention of the mathematics concept after the sixth grade students were treated with the concept attainment lesson was T1 X T2.

Design to Test the Second Hypothesis. The design for testing the second hypothesis regarding retention of the algebraic concept after the ninth grade students were treated with the concept attainment lesson was T1 X T2.

Design to Test the Third Hypothesis. The design for testing the third hypothesis regarding attitudes of the sixth grade students were treated with the concept attainment lesson was T1 X T2.

Design to Test the Fourth Hypothesis. The design for testing the fourth hypothesis regarding attitudes of the ninth grade students were treated with the concept attainment lesson was T1 X T2.

Treatment

Treatment to Test the First Hypothesis. The independent variable in the first hypothesis was the teaching of the concept attainment lesson to the sixth grade class. The dependent variable was the pretest and posttest. The treatment was administered over a one-class period.

Treatment to Test the Second Hypothesis. The independent variable in the second hypothesis was the teaching of the concept attainment lesson to the ninth grade class. The dependent variable was the pretest and posttest. The treatment was administered over a one-class period.

Treatment to Test the Third Hypothesis. The independent variable in the first hypothesis was the teaching of the concept attainment lesson to the sixth grade class. The dependent variable was the attitude toward the concept attainment lesson. The treatment was administered over a one-class period.

Treatment to Test the Fourth Hypothesis. The independent variable in the first hypothesis was the teaching of the concept attainment lesson to the ninth grade class. The dependent variable was the attitude toward the concept attainment lesson. The treatment was administered over a one-class period.

IV. RESULTS

Presentation of the Results

The primary purpose of this study was to determine the effectiveness of the concept attainment model of teaching in fostering student mastery by sixth and ninth grade students of the basic mathematics concept "prime number." The concept "prime number" is essential to the understanding of many mathematics and algebraic operations. Therefore, it is an important concept for students to master.

The second purpose of this study was to give the author the opportunity to determine whether both the content of "prime numbers" and the inductive thinking process skill can be taught concurrently using the concept attainment teaching model, a model which is within the information-processing family of teaching models. The Information Processing Family is a family of methods that directly teaches both content and intellectual process. Further, some research suggests that this family of models is more effective than other teaching methods, and that this family removes the traditional dichotomies between teaching content and intellectual processes (Joyce & Weil, 1992).

The third purpose of this study was to determine whether the attitudes of the sixth and ninth grade students toward the concept attainment model of teaching changed after having experienced a concept attainment model of teaching lesson on the concept "prime number." In teaching a previous sixth grade class, the author used the concept attainment model of teaching. All students enjoyed the variation in the teaching method used in class, and some enjoyed the problem solving that was required. However, some became frustrated when they could not solve the problem quickly and quit trying to solve the problem. The study measured the change in attitude of students experiencing the concept attainment model of teaching.

One of the school's general curriculum objectives was to help students to reason logically and independently, and to develop an attitude of inquiry. One of the school's target goals, listed in its "Target Goal and Implementation Plans" was that students would increase critical thinking skills (Hopfengardner, 1993). Therefore, a fourth purpose for this study was to begin meeting these goals by using the concept attainment model of teaching; it is a model of teaching that requires the use of critical thinking by students. According to Joyce and Weil (1992) the core of good thinking is the ability to problem solve, and the essence of problem solving is the ability to learn in puzzling situations. Learning how to learn or think is what school is all about, and the concept attainment model of teaching is one model that teaches students to learn to think.

The final purpose of this study was to apply the quasi-experimental approach to find out if this approach would be a useful and practical tool in determining whether a significant level of change in mastery level occurred as a result of the use of a model of teaching. If useful and practical, the author would build a database of statistical results comparing the effectiveness of different models of, or combination of models of, teaching for the same lesson concept.

The Sixth Grade Student Attitude Toward the Concept attainment Lesson. The author used the paired two sample t-test for means to compare the pretest and posttest student scores for each of the nineteen polar adjectives used in the semantic differential. The hypothesis was rejected for ten polar adjectives. There was a significant positive change in the students' attitudes toward the concept attainment model of teaching, which may be directly attributable to the concept attainment "prime number" lesson and not to chance. A test result summary table and a test results table for each polar adjective test is shown in APPENDIX L.

The Ninth Grade Student Attitude Toward the Concept Attainment Lesson. The author used the paired two sample t-test for means to compare the pretest and posttest student scores for each of the nineteen polar adjectives used in the semantic differential. The hypothesis was rejected for five polar adjectives. There was a significant positive change in the students' attitudes toward the concept attainment model of teaching which may be directly attributable to the concept attainment "prime number" lesson and not to chance. A test result summary table and a test results table for each polar adjective test is shown in APPENDIX M.

The Mastery of the Mathematics Concept by Sixth Grade Students. The author used the paired two sample t-test for means to compare the pretest and posttest student scores for the concept attainment concept "prime number." The hypothesis was rejected. There was a significant difference between the pretest and posttest scores of the students taking a concept attainment lesson on the concept "prime number." The test result table is shown in APPENDIX N.

The Mastery of the Algebraic Concept by Ninth Grade Students. The author used the paired two sample t-test for means to compare the pretest and posttest student scores for the concept attainment concept "prime number." There was a significant difference between the pretest and posttest scores of the students taking a concept attainment lesson on the concept "prime number." The hypothesis was rejected. The test result table is shown in APPENDIX O.

Discussion of the Quantitative Results

Attitudes of Sixth Grade Students. The semantic differential instrument contained 19 polar adjectives. A paired two sample t-test for means was performed using Microsoft's Office 97 Excel data analysis tool for each of the 19 polar adjectives. The statistics generated from the paired two sample t-test for means are in tables in APPENDIX L. Each of the 19 polar adjectives was tested against null hypothesis:

> No significant difference exists between the pretest and posttest mean attitude scores toward the concept attainment model of teaching by sixth grade students after being taught a lesson which uses the concept attainment model of teaching.

As the summary statistics show in table 4, APPENDIX L, the following 10 of the 19 polar adjective pairs tested at the significant difference level of .05. This means that for the 10 polar adjectives listed below, the null hypothesis was rejected. There was a significant positive change in the students' attitudes toward the concept attainment model of teaching which may be attributable to the concept attainment "prime number" lesson and not due to chance. It may be that because 19 paired two sample mean t-tests were conducted, the level of significance should be reflected at the .1 level instead. At the .1 level there is still a significant positive change.

Figure 4: Significant Sixth Grade Polar Adjectives

→		→
Passive	to	Active
Impulsive	to	Controlled
Rigid	to	Flexible
Bad	to	Good
Closed	to	Open
Chaotic	to	Ordered
Painful	to	Pleasurable
Negative	to	Positive
Dangerous	to	Safe
Worthless	to	Valuable

Attitudes of Ninth Grade Students. The semantic differential instrument contained 19 polar adjectives. A t-test paired two sample for means was performed using Microsoft's Office 97 Excel data analysis tool for each of the 19 polar adjectives. The statistics generated from the t-test paired two sample for means tests are in tables in APPENDIX M. A summary table of statistics is in table 24. Tables 25 through 43 are the statistic values for the 19 polar adjective pairs. Each of the 19 polar adjectives was tested against null hypothesis:

> No significant difference exists between the pretest and posttest mean attitude scores toward the concept attainment model of teaching by ninth grade students after being taught a lesson which uses the concept attainment model of teaching.

As the summary statistics show in table 24, the following 5 of the 19 polar adjective pairs tested at the significant difference level of .05.

Figure 5: Significant Ninth Grade Polar Adjectives

→		→
Confusing	to	Clear
Difficult	to	Easy
Bad	to	Good
Boring	to	Interesting
Unsuccessful	to	Successful

This means that for these 5 polar adjectives the null hypothesis was rejected. There was a significant positive change in the students' attitudes toward the concept attainment model of teaching which may be attributable to the concept attainment "prime number" lesson and not due to chance. It may be that because 19 paired two sample were conducted, the level of significance should be reflected at the .1 level instead. At the .1 level there is still a significant positive change.

Sixth Grade Student Concept Mastery. The null hypothesis was rejected. A significant difference existed between the pretest and posttest mean scores of sixth grade students who were exposed to the mathematics concept "prime number" using the concept attainment model of teaching. There was a significant difference measured between both the mathematics skill pretest and posttest, and the mathematics skill pretest and a second posttest. A t-test paired two sample for means was performed using Microsoft's Office 97 Excel data analysis tool. The statistics generated from the t-test paired two sample for means is shown in the table in APPENDIX N. The t critical one-tail value was 1.71714419. Any t-stat value higher than this constituted a significant difference at a significance level of .05. The t-stat for this t-test was 11.2146559. The P(T<=t) one-tail was 7.20949E-11. This means that the probability that this level of change could occur by chance was approximately 7 in 100 billion (100,000,000,000). Thus, the difference in the pretest and posttest scores was most probably the direct result of the concept attainment lesson and not a result of chance.

The t critical one-tail value for the second posttest was 1.70814019. Any t-stat value higher than this constituted a significant difference at a significance level of .05. The t-stat for this t-test was 11.60632476. The P(T<=t) one-tail was 7.31702E-12. This means that the probability that this level change could occur by chance was approximately 7 in 1 trillion (1,000,000,000,000). Thus, the difference in the pretest and posttest scores was most probably the result of the concept attainment lesson and not a result of chance.

<u>Ninth Grade Student Concept Mastery</u>. The null hypothesis was rejected. A significant difference existed between the pretest and posttest mean scores of ninth grade students who were exposed to the mathematics concept "prime number" using the concept attainment model of teaching. There was a significant difference measured between the Algebra I skill pretest and posttest. A t-test paired two sample for means was performed using Microsoft's Office 97 Excel data analysis tool. The statistics generated from the t-test paired two sample for means is shown the table in APPENDIX O. The t critical one tail value was 1.708140189. Any t-stat value higher than this constituted a significant difference at a significance level of .05. The t-stat for this t-test was 6.361416973. The P(T<=t) one-tail was 5.84138E-07. This means that the probability that this level change could occur by chance was approximately 6 in 10 million

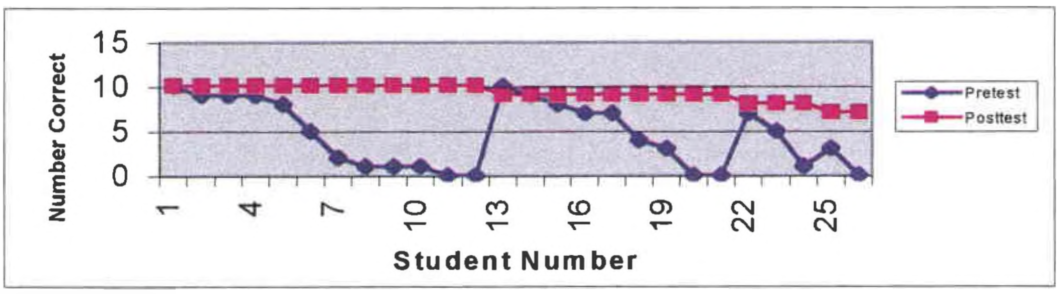
(10,000,000). Thus, the difference in the pretest and posttest scores was most probably the result of the concept attainment lesson and not a result of chance.

Discussion of the Qualitative Results Ninth Grade Results

The ninth grade mastery statistics showed a significant change between the pretest and posttest scores. That is, the results showed that the increase in student mastery for the concept "prime number" was most probably due to the concept attainment lesson, and not due to chance.

The change in ninth grade pretest and posttest scores is shown in the figure below. The pretest scores ranged between 0 to 10 out of 10 correct, while the posttest scores ranged between 7 and 10 out of 10 questions correct. Twelve ninth grade students scored 100% and nine scored 90% on the posttest.

Figure 6: Ninth Grade Pre/Posttest Comparison



The author's analysis of the missed posttest questions resulted in the following: Six ninth grade students missed the first question; one student correctly stated that the examples had only two factors, but did not state that the two factors were one and itself. This student also stated the numbers were negative. The other five students listed "prime number": as an attribute in addition to other irrelevant attributes. "Odd" was the irrelevant attribute given most often.

Only one ninth grade student missed test question number 2. This student identified only one of the two "prime numbers" from the unlabeled list of examples. This might be considered a student classification behavior outcome of undergeneralization; the student correctly identified one example, but missed the second example. This seems to be the case because the student correctly generated five "prime number" examples in answering question number 5.

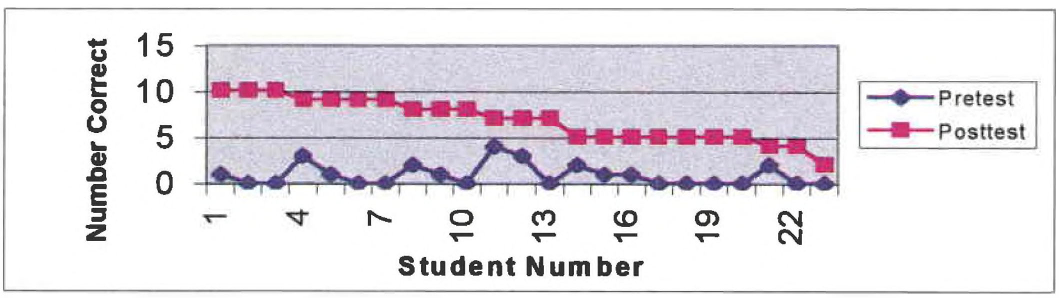
All the students who missed question 3 gave the concept name as "concept attainment." Question 4 asked the students to write the concept definition in their own words. All the students who missed question 4 described the concept attainment lesson process instead of giving the definition of the concept "prime number." In question 5, the students were asked to list five examples of the concept not already given on the test. Four students missed this question. One listed only two examples, both of which were correct. The other three students correctly listed four examples, and incorrectly listed one example. Two of these four listed the number "1" and one listed the number "65." The number "1" has only one factor, itself.

The number "65" has four factors, "1,""5,""13," and "65." All three of these errors are overgeneralization. Overgeneralization is the student classification behavior outcome in which the student lists a nonexample as an example in addition to giving a correct example.

Sixth Grade Results

The sixth grade mastery statistics also showed a significant change between the pretest and posttest scores. That is, the results showed that the increase in student mastery for the concept "prime number" was most probably due to the concept attainment lesson, and not due to chance. The probability the change was due to chance was very remote. The change in sixth grade pretest and posttest scores is shown in the figure below.

Figure 7: Sixth Grade Pre/Post Test Comparison



The graph shows the sixth grade students did learn, although only 3 scored 100% and 4 scored 90% on the posttest. None of the sixth grade students scored above 50% on the pretest. Pretest scores ranged from 0 to 5 points with 10 points possible. Thirteen of twenty-three students scored 70% or better on the posttest. Posttest scores ranged from 2 to 10 points with 10 points possible. All students scored higher on the posttest with 13 scoring 70% or above and ten scoring 50% or below.

The author's analysis of the missed posttest questions resulted in the following. Nine sixth grade students missed the first question. Three of six students gave the label "prime number" as the attribute. One of these two students gave incorrect attributes in addition to the label. One student did not answer the question. The other four students gave incorrect attributes or irrelevant attributes.

Eight students missed identifying the examples of the concept "prime number," question 2. One student correctly identified the number "37," but missed identifying the number "41," an outcome of undergeneralization. Five students overgeneralized by correctly identifying the numbers "37" and "41" as examples, but they also incorrectly identified the number "38" as an example. Two students missed questions classified as an outcome of misconception, because they identified the nonexamples ("38" and "42") as the examples.

Six students missed giving the name of the concept in question 3. One student did not answer the question. One student gave the name "math" instead of "prime number." Of the other four students, two gave the label "concept examples," one "concept attainment," and one "attributes."

Ten students missed writing the definition of the concept. One did not answer the question. Two addressed the concept attainment lesson process. Two gave the label "prime number," but did not give the essential attributes in the definition. The other five gave incorrect or irrelevant attributes.

By far, most students, 15 out of 23, missed generating their own list of examples of the concept, question 5. This predictably was the most difficult task for the sixth grade students.

Two students missed questions that could be categorized as misconceptions. One student's answer was a list of 5 attributes instead of 5 examples. The other student listed all nonexamples as examples.

All the other 13 students had errors that would be categorized as overgeneralizations, because all listed a combination of examples and nonexamples. Three students listed four examples and one odd nonexample. Five students listed three examples and two odd nonexamples. One student listed two examples and three odd nonexamples. One student listed two examples, one odd and two even nonexamples. One student listed two examples and two even nonexamples. One student listed only four numbers, two examples and two even nonexamples. Finally, another student listed only four numbers, one example and three even nonexamples.

Sixth Grade Test Comments

The author asked the twenty-three sixth grade students to write how well they felt they did on their tests. The responses of the twenty-two who responded are in APPENDIX K.

Thirteen of the twenty-three students scored between 70% and 100%. Ten scored 50% or below. Twelve of the 13 students with 70% to 100% made comments. One student who received a 100% stated, "I didn't quite understand everything, but I tried to do every problem." The other eleven said they either "understood," "know," "learned," "felt confident," or gave a similar response.

All ten of the students who scored 50% or below made comments. Four of the 10 students who scored 50% or less stated they did not understand or were confused. Two students stated they understood though one stated, "I understand but I don't think I did well on the test." The other 4 students thought they did well but their scores did not reflect their opinions.

Sixth Grade Learning Log Comments

The sixth grade students were asked to complete a learning log at the end of the concept attainment lesson. The students' learning log comments, shown in Appendix I, were very interesting. First, the students were open about their experiences, especially as to whether they thought they understood the lesson or not. The learning logs would be very helpful in planning a second concept attainment lesson; the purpose of which would be to bring the whole class to the concept attainment mastery level.

Second, an analysis of the comments of the students who said they understood revealed a pattern of four phases. In the beginning, phase I, these students felt bored or confused and thought the lesson was complicated or challenging. In phase II, they went through a transition period in which they began to understand. In phase III, they felt they had reached an understanding of the concept, and some reached a phase IV, in which they felt the lesson was fun or enjoyable.

Twelve of the 23 students commented that the lesson was fun. Two more stated they enjoyed the lesson. These 14 students also liked learning something new and being challenged.

One student of the remaining nine students seemed to be in Phase I saying, "I thought about the lesson. I thought it was ok. It was very confusing but worth the try." Three of the nine were in Phase II. One student said, "It's still confusing. I really don't get how it will help us later on. But I'm starting to understand it more and more." Another said, "It was kind of weird. It was pretty confusing, but I think I understand now." The third said, "It was complicated. I didn't understand it very much. I kind of understand this but I'll keep trying. The other five were in Phase III. One said, "…it was better at the end when I understood it." The second said, "…I began to understand. I sort of liked the lesson." The third student said, "I learned something. It was easy." The fourth said, "It is kind of easy, once you get the hang of it." The fifth student said, "I think the lesson was ok. I did learn something."

V. Summary, Conclusions, and Recommendations

Summary

Curriculum objectives of schools, as well as the National Council of Teachers of Mathematics, require teachers to help students learn to reason logically and independently, increase critical thinking skills, and develop an attitude of inquiry in learning mathematics concepts. The concept "prime number" is essential to the understanding of many mathematics and algebraic operations. Therefore, it an important concept for students to master. The Information Processing Family is a family of methods that directly teaches both content and the intellectual process. Research suggests that that this family of models is more effective than other teaching methods, and that this family removes the traditional dichotomies between teaching content and intellectual processes (Joyce & Weil, 1992). The concept attainment model of teaching is a member of the Information Processing Family of teaching models and one model of teaching that teaches students to learn to think (Joyce & Weil, 1992). Research of the literature confirmed the concept attainment model of teaching is a model of choice for teaching the concept "prime number."

The primary purpose of this study was to determine the effectiveness of the concept attainment model of teaching in fostering student mastery by sixth and ninth grade students of the basic mathematics concept "prime number." A second purpose was to give the author the opportunity to determine whether both the content of "prime numbers" and the inductive thinking process skill could practically be taught concurrently using the concept attainment model of teaching. A third purpose was to determine whether the attitudes of the sixth and ninth grade students toward the concept attainment model of teaching changed after having experienced a concept attainment model of teaching lesson on the concept "prime number." A fourth purpose was to apply the quasi-experimental approach to find out if it would be a useful and practical tool in determining whether a significant level of change in mastery level occurred as a result of the use of a model of teaching. The final purpose of this project was to use the concept attainment model of teaching to meet school and National Council of Teachers of Mathematics curriculum objectives.

The objective of this study was to evaluate the effectiveness of the concept model of teaching on student mastery of a sixth and ninth grade mathematics concept and to determine the students' attitudes toward this teaching method.

Four hypotheses were made. The first two centered on the sixth and ninth grade mastery of the concept "prime number." It was hypothesized that no significant difference would exist between the pretest and posttest mean scores of sixth grade and ninth grade students who had been exposed to a mathematics concept lesson using the concept attainment model of teaching. The second two hypotheses centered on student attitudes. It was hypothesized that no significant difference would exist between the pretest and posttest mean attitude scores toward the concept attainment model of teaching by sixth and ninth grade students after having been taught a lesson using the concept attainment model of teaching.

The subjects were 28 students taking sixth grade mathematics and 26 ninth grade students taking Algebra I. The sixth grade students were a heterogeneous group. Therefore, a full range of skill, motivation levels, and attitudes toward math should have been reflected. The ninth graders in Algebra I were selected using a placement test. Therefore, these students were expected to be high achievers, excellent students, and highly motivated.

The school where this study was conducted was a Kindergarten through 12 grade private parochial school. Approximately 350 students attend this school annually in a small city in Southwestern Ohio near Dayton, Ohio. Members of this community are oriented primarily toward the medical or other professional occupations.

Data were collected for the mastery of the concept "prime number" and the change in the attitude of students toward the concept attainment model of teaching using the successive administration of two parallel forms of the same instrument, one a mathematics test and a semantic differential, respectively.

The pretest and posttest were used because "in terms of test theory, this is the most desirable index of test reliability, since it involves two different representative samples of items" (Isaac and Michael, p.124). However, a limitation of this quasi-experiment is the test could not be validated.

The sixth grade mathematics and the ninth grade Algebra I skill pretests and posttests were parallel forms of a mathematics skill test on knowledge of the mathematics concept "prime number," its attributes, examples and definition. Each form consisted of approximately 10 questions addressing the definition, attributes, and recognition of examples of the concept "prime number." Questions were developed from existing mathematics tests and materials.

The sixth and ninth grade semantic differential pretests and posttests were parallel forms of a semantic differential on attitudes toward the concept attainment lesson. Each form consisted of 19 polar adjective pairs derived from Osgood's factor analyzed list and was designed to measure the students' attitude toward the concept attainment approach to learning (see Isaac & Michael, 1990).

In winter, 1996, the author administered first the semantic differential and then, the day after, the finalized form of the sixth grade mathematics skill pretest. Five days after the concept attainment lesson was given, the author administered the posttest. The next day, the sixth grade mathematics teacher administered the semantic differential posttest. Three weeks after the posttest, the author administered a second posttest, another parallel form of the sixth grade mathematics skill pretest.

In spring, 1995, the author administered first the semantic differential and then, the day after, the ninth grade Algebra I skill pretest. Two days after the concept attainment lesson was given, the author administered the posttest, followed by the semantic differential.

The design for testing each of the four hypotheses was T1 X T2. For each of the four hypotheses, the independent variable was the teaching of the concept attainment lesson, the dependent variable was the pretest and posttest, and the treatment was administered over a one-day period.

The results for the tests are as follows. The sixth and ninth grade students' attitude toward the concept attainment lesson changed. The author used the t-test paired two sample for means to compare the pretest and posttest student scores for each of the nineteen polar adjectives used in the semantic differential. The hypothesis was rejected for ten polar adjectives on the sixth grade semantic differential (see APPENDIX L). The hypothesis was rejected for five polar adjectives on the ninth grade polar adjectives (see APPENDIX M). There was a significant positive change in both the sixth and ninth grade students' attitudes toward the concept attainment model of teaching which may be attributable to the concept attainment "prime number" lesson and not due to chance.

The author also used the t-test paired two sample for means to compare the pretest and posttest student scores for the concept attainment concept "prime number." Both hypotheses were rejected. There was a significant difference between the students' pretest and posttest scores (see Appendices N and O).

Conclusions

The statistics show that the one concept attainment lesson was effective in increasing the sixth and ninth grade students' mastery of the concept "prime number." In addition, there was a positive change in attitude of the sixth and ninth grade students' attitudes toward the concept attainment method of teaching.

These sixth and ninth grade students were learning about both the inductive process of inquiry and the concept "prime number." The test results and the statistics showed these students did learn more about both. The sixth grade students were asked to keep a learning log on the concept attainment lesson. Eleven of the sixth grade students stated they had fun and one "enjoyed the lesson." All 22 statements showed that students believed they had learned or understood the concept.

The author suggests the initially low scores on the pretests for both the ninth and sixth grade students were partially due to the students' unfamiliarity with the inductive process and the concept attainment terminology and process. The author concludes that the increase in posttest scores reflected the students' understanding the concept attainment terminology in addition to the "prime number" concept itself. Some students in both classes gave "concept attainment" as the name of the concept and gave a definition of the concept attainment lesson process when asked for the concept definition. These students' answers showed that these students recalled that the concept attainment model of teaching was used to teach the lesson and they thought questions three and four were addressed the lesson instead of the mathematics concept "prime number.

The author further concludes some of the ninth grade students and a majority of the sixth grade students did not fully understand the difference between essential and irrelevant attributes and the difference between the concept name and the concept attributes. A second lesson was needed with these students in order ensure their understanding.

<u>Recommendations</u>

First, the author recommends teachers use the concept attainment model of teaching. The author was successful using this model of teaching to teach the significant mathematics concept, "prime number." The students were motivated by its use and enjoyed the intellectual challenge it provided.

Second, the author recommends elementary teachers initially use this model of teaching to teach mathematics concepts. All of the essential and irrelevant attributes for many of these concepts can be specified. Thus, it is possible to generate matched exemplar sets that completely represent these concepts. It is the author's opinion that such well-defined exemplar sets should be the easiest concept attainment lesson to teach.

Third, the author recommends teachers follow the steps delineated in the author's concept attainment model comparison chart (see table 1) and lesson syntax comparison chart (see APPENDIX R) when preparing a concept attainment lesson.

Fourth, the author recommends teachers read Lasley and Matczynski (1997), Joyce and Weil (1992), Eggen and Kauchak (1988), and Tennyson, Woolley, and Merrill (1972) in that order, to understand the model and its implementation. Lasley and Matczynski (1997) provide the most current and comprehensive textbook coverage of the concept attainment model's phases, defining syntax, critical phase elements, implementation, and evaluation. Their book is of the most practical value to the teacher. Joyce and Weil (1992) is recommended to be read next, because their book would reinforce what was learned by reading Lasley and Matczynski (1997), introduce additional definitions and syntax, and theory. Eggen and Kauchak's (1988) book, the most dated, still provides a good description of the concept attainment syntax and variations. Their book will further reinforce what the teacher has learned. Finally, the teacher should read Tennyson, Woolley, and Merrill, (1972) to get a concise but in-depth explanation of example divergence, non-example irrelevant attributes, and explanation of overgeneralization, undergeneralization, and misconception.

Fifth, the author recommends every teacher who is going to use this model of teaching, especially those in teacher preparation or masters programs, accomplish a concept analysis. This analysis is crucial in being able to identify a comprehensive exemplar set; that is, a range of exemplars which exhibits the full range of the critical attributes of the examples and the irrelevant attributes of the nonexamples.

Sixth, examples and nonexamples are most effective, i.e., likely to result in being correctly classified by students, if they are matched and divergent. Therefore, the author recommends teachers match the exemplars and ensure they display the full range of divergent attributes.

Seventh, the author recommends teachers use the "learning log" in place of a semantic differential to obtain student feedback about the lesson. The semantic differential is cumbersome to use and the students tire in using it. The learning log can be likened to a scientist's lab notebook, the students noting their experience with the inductive process hypotheses and their thoughts about process during the lesson. Students could then use these logs during a cooperative learning exercise for the application phase of the concept attainment lesson where the task would be for students to identify or create examples of the concept.

Eighth, the author recommends any teacher doing research on the effectiveness of the concept attainment model of teaching give a pretest and posttest and perform a paired t-test for sample means using Microsoft Excel's data analysis tool pack to test for a significance difference. However, the author recommends the teacher use a validated test, if possible, so the teacher can be more confident in the test results.

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APPENDICES

APPENDIX A: RATIONAL SET GENERATOR EXAMPLE

Figure 8: Annotated Rational Generator Model

General Theoretical Model of the Rational Set Generator Principle Defining attributes a, b, c Increasing Generalization Required			
Three Attributes a, b, and c	Teaching Example Class	Different Class Than Teaching Class, same Superordinate Class	Different Superordinate Class
a + b + c (examples)	easiest	↓ hard ↓→→ →→→ →→ →→	↓ ↓ harder
a + -b + -c (easier nonexamples)	hard	↓ ↓ harder ↓→→ →→→ →→ →→	↓ ↓ hardest ↓
a + b + -c (close-in nonexamples)	hardest	↓ ↓ harder hardest ↓→→ →→→ →→	Hardest hardest

Source: Driscoll, M.P. & Tessmer, M. (1985). The rational set generator: a method of creating concept examples for teaching and testing. Educational Technology, 63(1) p.30.

Note: The above model has been annotated to show how the examples go from easy to the more difficult. The upper left corner is the easiest, while the lower right corner is the hardest. Thus, in the physics example on the next page, the upper left box which contains the "A physicist uses an oven..." is the easiest example, while the lower right corner containing "A teacher runs a piece of chalk," is the most difficult. Please see the referenced article for an explanation of the model.

SUBJECT MATTER CLASSES

	Science Physics Chemistry	Technology Industry Engineering	Art Homemaking Business Recreation
Fusion(solid & solid to liquid)	A physicist uses an oven to convert aluminum to molten aluminum	A blast furnace converts iron ore to molten steel.	A burning candle heats its wax until the wax runs down the side in drops.
Sublimation (S& S to G)	A chemist electrifies a mound of sulfur, which release sulfur fumes.	A steel factory burns 10 tons of coal a day, which creates a lot of coal fumes.	A ranger burns a bunch of tree limbs to make a smoke signal.
Solidification (L & L to G)	A physics student puts some molten lead into the freezer to harden.	A blob of mud poured on a hot sidewalk soon becomes a pile of dirt.	After a volcanic eruption, lava cools to form lava rock.
Evaporation (L & L to G)	A bottle of alcohol is heated to release alcohol fumes.	A drill engine burns gasoline while it runs, which ends up as exhaust.	A glass of soda left outside soon will dry up and become part of the atmosphere.
Liquefaction (S& S to G)	A scientist sends electric jolts through a chamber of hydrogen and oxygen to create water.	A doctor closes a small would by pressing one piece of skin onto another one.	When the sky is hit by lightning bolts, rain is often created.
Cohesion (Same to Same)	A scientist discovers that glass plates can be joined by sliding one plate over another.	A mechanic notices that oil clings to his rubber gloves.	After a snowfall, a fresh layer of snow will cling to old layers of snow on the ground.
Adhesion (Different to Diff.)	When a chemist pushes a piece of steel next to a piece of aluminum, they stick together.	A mechanic notices that oil clings to his rubber gloves.	A teacher runs a piece of chalk across a blackboard, which leaves a white mark on the board.

Code to Abbreviations:

S= Solid, L= Liquid, G = Gas, S to L = Solid to Liquid change, etc. Same to Same = Same materials adheres to same material. Different to Diff. = Different material adheres to different.

Source: Driscoll, M.P. & Tessmer, M. (1985). The rational set generator: a method of creating concept examples for teaching and testing. Educational Technology, 63(1) p.30.

APPENDIX B: Semantic Differential for Sixth Grade Mathematics

Concept attainment

Important	__ :	__ :	__ :	__ :	__ :	__ :	__	unimportant
confusing	__ :	__ :	__ :	__ :	__ :	__ :	__	clear
flexible	__ :	__ :	__ :	__ :	__ :	__ :	__	rigid
passive	__ :	__ :	__ :	__ :	__ :	__ :	__	active
good	__ :	__ :	__ :	__ :	__ :	__ :	__	bad
successful	__ :	__ :	__ :	__ :	__ :	__ :	__	unsuccessful
interesting	__ :	__ :	__ :	__ :	__ :	__ :	__	boring
difficult	__ :	__ :	__ :	__ :	__ :	__ :	__	easy
mysterious	__ :	__ :	__ :	__ :	__ :	__ :	__	understandable
pleasurable	__ :	__ :	__ :	__ :	__ :	__ :	__	painful
relaxed	__ :	__ :	__ :	__ :	__ :	__ :	__	tense
work	__ :	__ :	__ :	__ :	__ :	__ :	__	fun
simple	__ :	__ :	__ :	__ :	__ :	__ :	__	complex
positive	__ :	__ :	__ :	__ :	__ :	__ :	__	negative
valuable	__ :	__ :	__ :	__ :	__ :	__ :	__	worthless
ordered	__ :	__ :	__ :	__ :	__ :	__ :	__	chaotic
dangerous	__ :	__ :	__ :	__ :	__ :	__ :	__	safe
controlled	__ :	__ :	__ :	__ :	__ :	__ :	__	impulsive
open	__ :	__ :	__ :	__ :	__ :	__ :	__	closed

APPENDIX C: Semantic Differential for Ninth Grade Algebra I

Concept attainment

Important	__ : __ : __ : __ : __ : __ : __	unimportant
confusing	__ : __ : __ : __ : __ : __ : __	clear
flexible	__ : __ : __ : __ : __ : __ : __	rigid
passive	__ : __ : __ : __ : __ : __ : __	active
good	__ : __ : __ : __ : __ : __ : __	bad
successful	__ : __ : __ : __ : __ : __ : __	unsuccessful
interesting	__ : __ : __ : __ : __ : __ : __	boring
difficult	__ : __ : __ : __ : __ : __ : __	easy
mysterious	__ : __ : __ : __ : __ : __ : __	understandable
pleasurable	__ : __ : __ : __ : __ : __ : __	painful
relaxed	__ : __ : __ : __ : __ : __ : __	tense
work	__ : __ : __ : __ : __ : __ : __	fun
simple	__ : __ : __ : __ : __ : __ : __	complex
positive	__ : __ : __ : __ : __ : __ : __	negative
valuable	__ : __ : __ : __ : __ : __ : __	worthless
ordered	__ : __ : __ : __ : __ : __ : __	chaotic
dangerous	__ : __ : __ : __ : __ : __ : __	safe
controlled	__ : __ : __ : __ : __ : __ : __	impulsive
open	__ : __ : __ : __ : __ : __ : __	closed

APPENDIX D: Ninth Grade Algebra Pretest

5/25/95

CONCEPT EXAMPLES	**NOT CONCEPT EXAMPLES**
2	4
3	16
5	30
11	32

UNLABELED EXAMPLES

17
18
20
23

1. List the unique characteristics (attributes) of the "**concept examples**" listed above.

2. Which of the numbers listed above as "**unlabeled examples**" are examples of the concept.

3. The name of the concept is __________________________

4. Write the definition of this concept in your own words.

5. List five examples of this concept that are not already listed on this paper.

APPENDIX E: Ninth Grade Algebra Posttest

5/31/95

CONCEPT EXAMPLES	**NOT CONCEPT EXAMPLES**
7	6
13	22
29	40
31	42

UNLABELED EXAMPLES

37
38
41
42

1. List the unique characteristics (attributes) of the **"concept examples"** listed above.

2. Which of the numbers listed above as "**unlabeled examples**" are examples of the concept.

3. The name of the concept is ____________________

4. Write the definition of this concept in your own words.

5. List five examples of this concept that are not already listed on this paper.

APPENDIX F: SIXTH GRADE MATHEMATICS PRETEST

2/5/96

CONCEPT EXAMPLES	**NOT CONCEPT EXAMPLES**
2	1
3	4
5	16
11	30
37	32

UNLABELED EXAMPLES

17
18
20
23

1. List the unique characteristics (attributes) of the "**concept examples**" listed above.
2. Which of the numbers listed above as "**unlabeled examples**" are examples of the concept.
3. The name of the concept is ________________________.
4. Write the definition of this concept in your own words.
5. List five examples of this concept that are not already listed on this paper.

APPENDIX G: Concept Attainment Lesson Plan

Math Lesson Plan for Teaching "Prime Numbers"

Concept Attainment Model

Objectives:

1. The student will be able to identify the attributes of a "prime number."

2. Given numbers, the student will be able to distinguish "prime numbers" from those that are not "prime numbers."

3. The student will be able to define a "prime number" in her/his own words.

Method: Concept Attainment.

Procedure: Conduct the lesson as outlined in the "Models of Teaching" textbook (see next page).

Materials:

1. Prime Number Lesson in textbook, pg. 232.

2. Reference sheet with prime and non-"prime numbers" (see attachment(s)).

3. Learning log sheets (see attachment).

Evaluation:

The students will be evaluated by their responses during the lesson, on daily assignments and on the formative evaluation.

Presentation

1. Introduce the lesson. Have students prepared with paper on which to keep notes.

Say: "Students I have a concept in mind."

"This is an example of the concept I have in mind. This is a yes and this is a no. (Show the first set of numbers.)

"Take a look at these two numbers. How are they alike and how are they different? The yes has the attributes, or characteristics, of our category, the no does not."

3. Present the lesson. Show the second set of numbers on the chalkboard.

Say: "Now examine these numbers. This number has the attributes we are concerned with; this number does not. What do these two numbers have in common that these two numbers do not?"

4. Show another set of numbers.

Say: " What do the yes's have in common that they do not share with the no's?

"Now, what do you see? Please write down your hypothesis at this point. What do think are the attributes that the yes's have in common that they do not share with the no's (Pause so the students can write.)

"Did any of you have to change your ideas?"

5. Go through the numbers as necessary, and give explanation as necessary.

6. Phase II: Testing Attainment of the Concept. Have students identify additional examples of unlabeled examples as yes and no. Confirm the hypotheses, name concept, and restate the definition according to the essential attribute(s).

7. Phase Three: Analysis of Thinking Strategies. The students are to write a learning log entry for this lesson.

Initial Exemplar Examples

Examples	Nonexamples
2	4
3	6
5	15
11	30
29	100
53	126

Unlabeled Examples

20
17
23
16
52

APPENDIX H: Sample Sixth Grade Student Learning Log

LEARNING LOG

These are my thoughts about: ______________________________

APPENDIX I: Sixth Grade Student Learning Log Comments

1. It was kind of boring in the beginning. but it was better at the end when I understood it.

2. It is a little tricky, but once you get a hand of it is really fun. I had no idea of what it was and I did it a little while and I really like it.

3. It was not fun at first. But after I learned what it was, it was pretty fun. And I am glad I learned something new.

4. It was confusing at first. Then I began to understand. I sort of liked the lesson. Mrs. Fitch is a good teacher. (smiley face)

5. I thought about this lesson. I thought it was ok. It was very confusing but worth the try.

6. It was okay, but it was sort of boring. I learned something. It was easy.

7. It was complicated. I didn't understand it very much. I kind of understand this but I'll keep trying.

8. Today it was fun and made you use your brain. I came up with the solution so I feel good about it because it was scrambling my brain. I recommend that teachers do it far more.

9. I like the way of teaching. It was hard to catch on, but once I did, It was fun!

10. I think the lesson was ok. I did learn something.

11. It's still confusing. I really don't get how it will help us later on. But I'm starting to understand it more and more.

12. I learned how to figure out "prime numbers." I thought it was tons of fun.

13. I thought the lesson was easy and I liked the way we tried everything and then she has us guess. At first it was boring, then once you understand, it is a little fun.

14. I liked it because it was fun to learn.

15. It was kind of weird. It was pretty confusing, but I think I understand now.

16. At first it was hard. But then I started to understand it. It was really interesting. I enjoyed this session.

17. It's okay. It's sort of easy, it's fun to do it, like our math challenge kind of brainteasers.

18. I think the lesson is kind of boring. But it is sort of fun in a way.

19. I thought this lesson was fun. I learned some new stuff, like the differences between "prime numbers" and other numbers.

20. I thought the lesson was boring at first. Then after I figured it out it was fun!!!

21. I thought it was fun to guess and make observations. It was challenging.

22. It is kind of easy, once you get the hang of it.

23. I enjoyed this lesson. It had a lot of logical guessing and it was a challenge

APPENDIX J: Sixth Grade Posttest
2/12/96

CONCEPT EXAMPLES	**NOT CONCEPT EXAMPLES**
2	1
7	6
13	22
29	40
31	42

UNLABELED EXAMPLES

37
38
41
42

1. List the unique characteristics (attributes) of the **"concept examples"** listed above.

2. Which of the numbers listed above as "**unlabeled examples"** are examples of the concept.

3. The name of the concept is __________________________

4. Write the definition of this concept in your own words.

5. List five examples of this concept that are not already listed on this paper.

APPENDIX K: Sixth Grade Posttest Student Comments

	Pretest	Posttest	
1	10%	100%	I don't quite understand what everything, but I tried to do every problem.
2	0%	100%	I understand this concept.
3	0%	100%	I felt confident.
4	0%	90%	I understand very well.
5	0%	90%	I'm pretty sure I know it and I am understanding it a lot better.
6	30%	90%	I only had trouble on number 3.
7	10%	90%	I think I did well on it and understand it.
8	0%	80%	I feel I did good on this test.
9	10%	80%	I know what you're talking about.
10	20%	80%	I understand this lesson and think I did pretty good on this test.
11	30%	70%	I feel good about this test. I feel I learned. I know I did much better on this test that I did on the pre-test Iam NOT in the dark.
12	0%	70%	(no comment)
13	40%	70%	I understand this lesson.
14	10%	50%	I feel I did ok on this test. I sort of a don't understand it.
15	10%	50%	I feel I don't really understand this.
16	0%	50%	I understand.
17	0%	50%	I understand it, but I don't think I did well on the test.
18	0%	50%	Am confused. I sort of forgot how to do it.
19	0%	50%	I think I did pretty bad. I didn't understand.
20	20%	50%	I feel ok about this test.
21	20%	40%	Yes. I really like this test, because it was simple after I got the hang of it.
22	0%	40%	I feel I was successful on this test.
23	0%	20%	I just could not remember number 3, but it was fun.

APPENDIX L: Sixth Grade Semantic Differential Test Results

Table 4: SIXTH GRADE STATISTICS SUMMARY TABLE

	t Stat	P(T<=t) one-tail	t Critical one-tail	df	Obser-vations	Mean	Standard Deviation
C.A.I-1	**11.2146559**	**7.20949E-11**	1.71714419	22	23	6.7826087	2.295381167
C.A.I-2	**11.60632476**	**7.31702E-12**	1.70814019	25	26	6.65384615	2.296820545
active	**2.223322207**	0.018150397	1.71387001	23	24	5.04166667	1.731527766
clear	0.589870238	0.280514257	1.71387001	23	24	4.79166667	1.84105751
controlled	**2.807333055**	0.00500003	1.71387001	23	24	6.04166667	1.232853412
easy	1.109623082	0.139314448	1.71387001	23	24	4.625	1.526932133
flexible	**3.431617694**	0.001138512	1.71387001	23	24	5.45833333	1.284664283
fun	0.341688848	0.367843652	1.71387001	23	24	4.41666667	1.791687732
good	**2.570795952**	0.008717816	1.71714419	22	23	5.91304348	1.239979599
important	1.616783194	0.05977989	1.71387001	23	24	5.66666667	1.493949148
interesting	1.345614465	0.095771607	1.71387001	23	24	5.54166667	1.864523874
open	**2.738858833**	0.005848907	1.71387001	23	24	5.625	1.408437309
ordered	**2.360830929**	0.01354274	1.71387001	23	24	5.58333333	1.282547284
pleasurable	**2.086664004**	0.024360215	1.71714419	22	23	5.2173913	1.204405615
positive	**2.473152546**	0.010605625	1.71387001	23	24	5.79166667	1.531670491
relaxed	1.670707077	0.054166709	1.71387001	23	24	5	1.793708813
safe	**2.183732652**	0.019719509	1.71387001	23	24	6.125	1.329023833
simple	-0.17316744	0.432017381	1.71387001	23	24	3.75	1.750776225
successful	1.515027016	0.072001093	1.71714419	22	23	5.65217391	1.721751108
Under-standable	0.992831449	0.165561534	1.71387001	23	24	4.83333333	1.809796209
valuable	**2.041515426**	0.026416774	1.71387001	23	24	5.875	1.153915828

Table 5: SIXTH GRADE SEMANTIC DIFFERENTIAL IMPORTANT MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	important posttest	important pretest
Mean	5.666667	5.125
Variance	2.231884	1.331521739
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	1.616783	
P(T<=t) one-tail	0.05978	
t Critical one-tail	1.71387	

Table 6: SIXTH GRADE SEMANTIC DIFFERENTIAL CLEAR MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	clear posttest	clear pretest
Mean	4.791667	4.5
Variance	3.389493	2.434782609
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	0.58987	
P(T<=t) one-tail	0.280514	
t Critical one-tail	1.71387	

Table 7: SIXTH GRADE SEMANTIC DIFFERENTIAL FLEXIBLE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	Flexible posttest	flexible pretest
Mean	5.458333	4.125
Variance	1.650362	1.418478261
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	3.431618	
P(T<=t) one-tail	0.001139	
t Critical one-tail	1.71387	

Table 8: SIXTH GRADE SEMANTIC DIFFERENTIAL ACTIVE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	active posttest	active pretest
Mean	5.041667	4.125
Variance	2.998188	1.070652174
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	2.223322	
P(T<=t) one-tail	0.01815	
t Critical one-tail	1.71387	

Table 9: SIXTH GRADE SEMANTIC DIFFERENTIAL GOOD MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	good	good
	posttest	pretest
Mean	5.913043	5
Variance	1.537549	2
Observations	23	23
Hypothesized Mean Difference	0	
Df	22	
t Stat	2.570796	
P(T<=t) one-tail	0.008718	
t Critical one-tail	1.717144	

Table 10: SIXTH GRADE SEMANTIC DIFFERENTIAL SUCCESSFUL MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	successful	successful
	posttest	pretest
Mean	5.652174	4.913043478
Variance	2.964427	1.537549407
Observations	23	23
Hypothesized Mean Difference	0	
Df	22	
t Stat	1.515027	
P(T<=t) one-tail	0.072001	
t Critical one-tail	1.717144	

Table 11: SIXTH GRADE SEMANTIC DIFFERENTIAL INTERESTING MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means	interesting posttest	Interesting Pretest
Mean	5.541667	4.833333333
Variance	3.476449	2.057971014
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	1.345614	
P(T<=t) one-tail	0.095772	
t Critical one-tail	1.71387	

Table 12: SIXTH GRADE SEMANTIC DIFFERENTIAL EASY MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means	easy posttest	easy Pretest
Mean	4.625	4.208333333
Variance	2.331522	1.911231884
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	1.109623	
P(T<=t) one-tail	0.139314	
t Critical one-tail	1.71387	

Table 13: SIXTH GRADE SEMANTIC DIFFERENTIAL UNDERSTAND MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	understandable	understandable
	posttest	pretest
Mean	4.833333	4.333333333
Variance	3.275362	2.579710145
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	0.992831	
P(T<=t) one-tail	0.165562	
t Critical one-tail	1.71387	

Table 14: SIXTH GRADE SEMANTIC DIFFERENTIAL PLEASURE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	pleasurable	pleasurable
	posttest	pretest
Mean	5.217391	4.391304348
Variance	1.450593	1.43083004
Observations	23	23
Hypothesized Mean Difference	0	
Df	22	
t Stat	2.086664	
P(T<=t) one-tail	0.02436	
t Critical one-tail	1.717144	

Table 15: SIXTH GRADE SEMANTIC DIFFERENTIAL RELAXED MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means	relaxed	relaxed
	posttest	pretest
Mean	5	4.166666667
Variance	3.217391	1.449275362
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	1.670707	
P(T<=t) one-tail	0.054167	
t Critical one-tail	1.71387	

Table 16: SIXTH GRADE SEMANTIC DIFFERENTIAL FUN MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means	fun	fun
	posttest	pretest
Mean	4.416667	4.25
Variance	3.210145	2.02173913
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	0.341689	
P(T<=t) one-tail	0.367844	
t Critical one-tail	1.71387	

Table 17: SIXTH GRADE SEMANTIC DIFFERENTIAL SIMPLE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	simple	simple
	posttest	pretest
Mean	3.75	3.833333333
Variance	3.065217	1.971014493
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	-0.17317	
P(T<=t) one-tail	0.432017	
t Critical one-tail	1.71387	

Table 18: SIXTH GRADE SEMANTIC DIFFERENTIAL POSITIVE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	positive	positive
	posttest	pretest
Mean	5.791667	4.875
Variance	2.346014	1.244565217
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	2.473153	
P(T<=t) one-tail	0.010606	
t Critical one-tail	1.71387	

Table 19: SIXTH GRADE SEMANTIC DIFFERENTIAL VALUABLE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means	valuable posttest	valuable pretest
Mean	5.875	5.125
Variance	1.331522	1.679347826
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	2.041515	
P(T<=t) one-tail	0.026417	
t Critical one-tail	1.71387	

Table 20: SIXTH GRADE SEMANTIC DIFFERENTIAL ORDERED MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means	ordered posttest	ordered pretest
Mean	5.583333	4.625
Variance	1.644928	2.070652174
Observations	24	24
Hypothesized Mean Difference	0	
Df	23	
t Stat	2.360831	
P(T<=t) one-tail	0.013543	
t Critical one-tail	1.71387	

Table 21: SIXTH GRADE SEMANTIC DIFFERENTIAL SAFE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	safe posttest	safe pretest
Mean	6.125	5.25
Variance	1.766304	2.369565217
Observations	24	24
Hypothesized Mean Difference	0	
df	23	
t Stat	2.183733	
P(T<=t) one-tail	0.01972	
t Critical one-tail	1.71387	

Table 22: SIXTH GRADE SEMANTIC DIFFERENTIAL CONTROLLED MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	controlled posttest	controlled pretest
Mean	6.041667	4.875
Variance	1.519928	1.766304348
Observations	24	24
Hypothesized Mean Difference	0	
df	23	
t Stat	2.807333	
P(T<=t) one-tail	0.005	
t Critical one-tail	1.71387	

Table 23: SIXTH GRADE SEMANTIC DIFFERENTIAL OPEN MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	open posttest	open pretest
Mean	5.625	4.708333
Variance	1.983696	1.259058
Observations	24	24
Hypothesized Mean Difference	0	
df	23	
t Stat	2.738859	
P(T<=t) one-tail	0.005849	
t Critical one-tail	1.71387	

APPENDIX M: Ninth Grade Semantic Differential Test Results

Table 24: NINTH GRADE STATISTICS SUMMARY TABLE

	t Stat	P(T<=t) one-tail	t Critical one-tail	df	Obser-vations	Mean	Standard Deviation
C.A.I	**6.361416973**	5.84138E-07	1.708140189	25	26	9.19230769	0.938902797
active	0.253320199	0.401089081	1.710882316	24	25	4.64	1.680277755
clear	**2.813342073**	0.00481298	1.710882316	24	25	5.04	1.593737745
controlled	0.241501983	0.405608771	1.710882316	24	25	3.36	1.604161255
easy	**1.97066959**	0.030200748	1.710882316	24	25	4.72	1.83757086
flexible	0.096477834	0.461988412	1.713870006	23	24	4.70833333	1.82921144
fun	1.218142425	0.117759412	1.713870006	23	24	3.75	1.621861518
good	**2.573070084**	0.008344053	1.710882316	24	25	4.64	1.629928424
important	1.27220893	0.107743849	1.710882316	24	25	4.4	1.755942292
interesting	**2.228173626**	0.017966117	1.713870006	23	24	3.95833333	2.312144998
open	-0.646996639	0.261887281	1.710882316	24	25	4.56	1.685229955
ordered	-1.830417261	0.039817244	1.710882316	24	25	3.28	1.429452109
pleasurable	0.594088526	0.279005939	1.710882316	24	25	4.04	1.670329309
positive	1.428869017	0.082964441	1.710882316	24	25	4.24	1.3
relaxed	1.036322583	0.155190569	1.710882316	24	25	4.68	1.749285568
safe	-1.110695665	0.138851785	1.710882316	24	25	4.4	1.632993162
simple	1.044465936	0.15333826	1.710882316	24	25	4.4	1.870828693
successful	**2.021164611**	0.027276042	1.710882316	24	25	4.72	1.904380914
under-standable	1.38873015	0.088834577	1.710882316	24	25	4.88	1.921804707
valuable	1.138028827	0.133171041	1.710882316	24	25	4.04	1.790716802

Table 25: NINTH GRADE SEMANTIC DIFFERENTIAL IMPORTANT MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	important	important
	posttest	pretest
Mean	4.4	3.88
Variance	3.083333	1.776666667
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	1.272209	
P(T<=t) one-tail	0.107744	
t Critical one-tail	1.710882	

Table 26: NINTH GRADE SEMANTIC DIFFERENTIAL CLEAR MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	clear	clear
	posttest	pretest
Mean	5.04	3.8
Variance	2.54	2.75
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	2.813342	
P(T<=t) one-tail	0.004813	
t Critical one-tail	1.710882	

Table 27: NINTH GRADE SEMANTIC DIFFERENTIAL FLEXIBLE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	flexible posttest	flexible pretest
Mean	4.708333	4.666666667
Variance	3.346014	3.101449275
Observations	24	24
Hypothesized Mean Difference	0	
df	23	
t Stat	0.096478	
P(T<=t) one-tail	0.461988	
t Critical one-tail	1.71387	

Table 28: NINTH GRADE SEMANTIC DIFFERENTIAL ACTIVE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	active posttest	active pretest
Mean	4.64	4.56
Variance	2.823333	1.256666667
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	0.25332	
P(T<=t) one-tail	0.401089	
t Critical one-tail	1.710882	

Table 29: NINTH GRADE SEMANTIC DIFFERENTIAL GOOD MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	good posttest	good pretest
Mean	4.64	3.84
Variance	2.656667	1.64
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	2.57307	
P(T<=t) one-tail	0.008344	
t Critical one-tail	1.710882	

Table 30: NINTH GRADE SEMANTIC DIFFERENTIAL SUCCESSFUL MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	successful posttest	successful pretest
Mean	4.72	3.92
Variance	3.626667	2.076666667
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	2.021165	
P(T<=t) one-tail	0.027276	
t Critical one-tail	1.710882	

Table 31: NINTH GRADE SEMANTIC DIFFERENTIAL INTERESTING MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	interesting posttest	interesting pretest
Mean	3.958333	3.375
Variance	5.346014	2.331521739
Observations	24	24
Hypothesized Mean Difference	0	
df	23	
t Stat	2.228174	
P(T<=t) one-tail	0.017966	
t Critical one-tail	1.71387	

Table 32: NINTH GRADE SEMANTIC DIFFERENTIAL EASY MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	easy posttest	easy pretest
Mean	4.72	4.04
Variance	3.376667	1.79
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	1.97067	
P(T<=t) one-tail	0.030201	
t Critical one-tail	1.710882	

Table 33: NINTH GRADE SEMANTIC DIFFERENTIAL UNDERSTAND MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	understandable	understandable
	posttest	pretest
Mean	4.88	4.28
Variance	3.693333333	2.21
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	1.38873015	
P(T<=t) one-tail	0.088834577	
t Critical one-tail	1.710882316	

Table 34: NINTH GRADE SEMANTIC DIFFERENTIAL PLEASURE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	pleasurable	pleasurable
	posttest	pretest
Mean	4.04	3.84
Variance	2.79	0.556666667
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	0.5940885	
P(T<=t) one-tail	0.2790059	
t Critical one-tail	1.7108823	

Table 35: NINTH GRADE SEMANTIC DIFFERENTIAL RELAXED MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	relaxed	relaxed
	posttest	pretest
Mean	4.68	4.24
Variance	3.06	1.19
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	1.036323	
P(T<=t) one-tail	0.155191	
t Critical one-tail	1.710882	

Table 36: NINTH GRADE SEMANTIC DIFFERENTIAL FUN MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	fun	fun
	posttest	pretest
Mean	3.75	3.416666667
Variance	2.630435	1.81884058
Observations	24	24
Hypothesized Mean Difference	0	
df	23	
t Stat	1.218142	
P(T<=t) one-tail	0.117759	
t Critical one-tail	1.71387	

Table 37: NINTH GRADE SEMANTIC DIFFERENTIAL SIMPLE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	simple posttest	simple pretest
Mean	4.4	4
Variance	3.5	1
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	1.044466	
P(T<=t) one-tail	0.153338	
t Critical one-tail	1.710882	

Table 38: NINTH GRADE SEMANTIC DIFFERENTIAL POSITIVE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	Positive Posttest	positive pretest
Mean	4.24	3.96
Variance	1.69	1.54
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	1.428869	
P(T<=t) one-tail	0.082964	
t Critical one-tail	1.710882	

Table 39: NINTH GRADE SEMANTIC DIFFERENTIAL VALUABLE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	Valuable	valuable
	Posttest	pretest
Mean	4.04	3.72
Variance	3.206667	1.793333333
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	1.138029	
P(T<=t) one-tail	0.133171	
t Critical one-tail	1.710882	

Table 40: NINTH GRADE SEMANTIC DIFFERENTIAL SAFE MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	Safe	safe
	Posttest	pretest
Mean	4.4	4.84
Variance	2.666667	1.64
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	-1.1107	
P(T<=t) one-tail	0.138852	
t Critical one-tail	1.710882	

Table 41: NINTH GRADE SEMANTIC DIFFERENTIAL ORDERED MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	Ordered Posttest	ordered pretest
Mean	3.28	3.84
Variance	2.043333	1.223333333
Observations	25	25
Hypothesized Mean Difference	0	
df	24	
t Stat	-1.83042	
P(T<=t) one-tail	0.039817	
t Critical one-tail	1.710882	

Table 42: NINTH GRADE SEMANTIC DIFFERENTIAL CONTROLLED MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	Controlled Posttest	controlled pretest
Mean	3.36	3.28
Variance	2.573333	1.376666667
Observations	25	25
Hypothesized Mean Difference	0	
Df	24	
t Stat	0.241502	
P(T<=t) one-tail	0.405609	
t Critical one-tail	1.710882	

Table 43: NINTH GRADE SEMANTIC DIFFERENTIAL OPEN MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	Open	Open
	Posttest	Pretest
Mean	4.56	4.8
Variance	2.84	2.166667
Observations	25	25
Hypothesized Mean Difference	0	
Df	24	
t Stat	-0.647	
P(T<=t) one-tail	0.261887	
t Critical one-tail	1.710882	

APPENDIX N: SIXTH GRADE FIRST POSTTEST MASTERY RESULTS

Table 44: SIXTH GRADE "PRIME NUMBER" MASTERY MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	2/12/96	2/5/96
	Posttest	Pretest
Mean	6.782609	0.913043
Variance	5.268775	1.44664
Observations	23	23
Hypothesized Mean Difference	0	
Df	22	
t Stat	11.21466	
P(T<=t) one-tail	7.21E-11	Significant
t Critical one-tail	1.717144	

Table 45: SIXTH GRADE SECOND POSTTEST MASTERY RESULTS MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	3/4/96	2/5/96
	2nd posttest	Pretest
Mean	6.653846154	1.038461538
Variance	5.275384615	1.958461538
Observations	26	26
Hypothesized Mean Difference	0	
Df	25	
t Stat	11.60632476	
P(T<=t) one-tail	7.31702E-12	Significant
t Critical one-tail	1.708140189	

APPENDIX O: Ninth Grade POSTTEST MASTERY Results

Table 46: NINTH GRADE "PRIME NUMBER" MASTERY MEANS, STANDARD DEVIATIONS, AND t VALUE

t-Test: Paired Two Sample for Means		
	Posttest	pretest
Mean	9.192308	4.576923
Variance	0.881538	13.85385
Observations	26	26
Hypothesized Mean Difference	0	
Df	25	
t Stat	6.361417	
P(T<=t) one-tail	5.84E-07	significant
t Critical one-tail	1.70814	

APPENDIX P: Numbered Semantic Differential Table

Arranged as in pretest and posttest

Polar Adjective								Polar Adjective
Important	7	6	5	4	3	2	1	Unimportant
confusing	1	2	3	4	5	6	7	Clear
flexible	7	6	5	4	3	2	1	Rigid
passive	1	2	3	4	5	6	7	Active
good	7	6	5	4	3	2	1	Bad
successful	7	6	5	4	3	2	1	Unsuccessful
interesting	7	6	5	4	3	2	1	Boring
difficult	1	2	3	4	5	6	7	Easy
mysterious	1	2	3	4	5	6	7	Understandable
pleasurable	7	6	5	4	3	2	1	Painful
relaxed	7	6	5	4	3	2	1	Tense
work	1	2	3	4	5	6	7	Fun
simple	1	2	3	4	5	6	7	Complex
positive	7	6	5	4	3	2	1	Negative
valuable	7	6	5	4	3	2	1	Worthless
ordered	7	6	5	4	3	2	1	Chaotic
dangerous	1	2	3	4	5	6	7	Safe
controlled	7	6	5	4	3	2	1	Impulsive
open	7	6	5	4	3	2	1	Closed

APPENDIX Q: Numbered Semantic Differential Table

Arranged 1-7

Polar Adjective								Polar Adjective
unimportant	1	2	3	4	5	6	7	Important
confusing	1	2	3	4	5	6	7	Clear
rigid	1	2	3	4	5	6	7	Flexible
passive	1	2	3	4	5	6	7	Active
bad	1	2	3	4	5	6	7	Good
unsuccessful	1	2	3	4	5	6	7	Successful
boring	1	2	3	4	5	6	7	Interesting
difficult	1	2	3	4	5	6	7	Easy
mysterious	1	2	3	4	5	6	7	Understandable
painful	1	2	3	4	5	6	7	Pleasurable
tense	1	2	3	4	5	6	7	Relaxed
work	1	2	3	4	5	6	7	Fun
simple	1	2	3	4	5	6	7	Complex
negative	1	2	3	4	5	6	7	Positive
worthless	1	2	3	4	5	6	7	Valuable
chaotic	1	2	3	4	5	6	7	Ordered
dangerous	1	2	3	4	5	6	7	Safe
impulsive	1	2	3	4	5	6	7	Controlled
closed	1	2	3	4	5	6	7	Open

APPENDIX R: Author's Lesson Syntax Comparison Chart

Eggen	Joyce	Lasley
Implementing concept Attainment Activities Concept Attainment I	**Phase One: Presentation of Data and Identification of Concept**	**Phase II. Exemplar Identification Phase III: Hypothesizing**
a. Present the exemplar with the selected headings.	Teacher present labeled examples.	Teacher presents (matched or unmatched) exemplars.
b. Ask students to hypothesize possible categories.	Students compare attributes in positive and negative examples.	Students analyze exemplars and generate hypotheses.
c. Present next exemplar	Students generate and test hypotheses.	Teacher presents additional exemplars.
d. Continue exemplar presentation and hypothesizing until the hypothesis encompasses all the isolated data.	Students state a definition according to the essential attributes.	Students add additional hypotheses and eliminate invalid hypotheses.
e. Evaluate students' mastery	**Phase Two: Testing Attainment of the Concept**	Teacher and students confirm all valid and eliminate all invalid hypotheses.
f. Provide analysis of concepts characteristics	Students identify additional unlabeled examples as yes or no	**Phase IV: Closure**
	Teacher confirms hypotheses, names concept, and restates definitions according to essential attributes.	Review remaining hypotheses and help students isolated concept label. (Least amount of teaching time.)
	Students generate examples.	Review and demonstrate why the concept attributes define whether an item is a positive or negative example.
	Phase Three: Analysis of Thinking Strategies	**Phase V: Application**
	Students describe thoughts.	Students create their own exemplars, positive and negative.
	Students discuss role of hypothesis and attributes.	Teacher more fully explores the differences between relevant and irrelevant attributes.
	Students discuss type and number of hypotheses.	