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COGNITIVE APPRENTICESHIP: AUTHENTIC PROBLEM-SOLVING
EXPERIENCES CHALLENGES TRADITIONAL ISOLATED
LEARNING OUTCOMES

by
Nancy R. Peterson

A Thesis

Submitted in partial fulfillment of the requirements of the
Master of Arts Degree in the Graduate Division
of Rowan College

Approved by

Professor

Date Approved April 3, 1995

ABSTRACT

Nancy R. Peterson

Cognitive apprenticeship: authentic problem-solving experiences challenges traditional isolated learning outcomes

1995

Thesis Advisor: Dr. Stanley Urban
Learning Disabilities

This study was designed to determine if seventh grade basic skills and special education students who experienced different teaching styles would demonstrate an increased ability to solve problems on a criterion-referenced test. Pre and post testing requiring multiple choice responses, were given to a sample of 27 seventh grade students. The Control group consisted of 11 BSI students while the experimental group of sixteen students contained 6 classified, 2 ESL students, and 8 borderline BSI students.

A task performance project, *Games-Recycled Math*, in which students of the experimental group planned, designed, and constructed a mathematical game, was designed and implemented over a four month period. The control group was taught through traditional teaching techniques utilizing paper and pencil tasks and focusing on mechanical steps applied in isolated contexts.

Data, based on t-statistics, revealed no significant impact from the different teaching techniques. However, individual comparisons revealed within the experimental group that the 2 ESL students demonstrated a 28% and 29% improvement in their scores. Classified students demonstrated increases of 32%, 18%, 18%, and 3%. Although the results cannot be labeled conclusive, they suggest serious consideration be given towards the cognitive apprenticeship model for students with disabilities.

MINI-ABSTRACT

Nancy R. Peterson

Cognitive apprenticeship: authentic problem-solving experiences challenges traditional isolated learning outcomes

1995

Thesis Advisor: Dr. Stanley Urban

This study was designed to determine if seventh grade basic skills and special education students who were presented with different teaching styles would demonstrate an increased ability to solve problems on a criterion-referenced test requiring a multiple choice response. Results showed no significant effect of teaching styles upon the overall groups, however, within the experimental group, ESL and classified students demonstrated improvements in their scores.

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CHAPTER I

THE PROBLEM

Recent research has provided a discouraging picture of student achievement in mathematics at all grade levels (e.g., Anrig & Lapointe, 1989; Byrne, 1989). Byrne found: "Most American students leave school with such a poor understanding of mathematics that they cannot adequately perform the vast majority of jobs, much less consider specialized careers in mathematics or science" (p. 597). Almost half of the over 3 million students who were high school juniors and seniors during the 1989-1990 school year finished school without mastering 8th-grade mathematics (Anrig & Lapointe, 1989). These deficiencies in the general education population are shocking, but the continuing failure of students with mild disabilities to master basic skills math is even more outrageous. Making matters worse, the investigation and remediation of mathematics performance deficiencies among students with learning disabilities has not received the same level of attention as other areas, such as reading and language (Bender, 1992).

PURPOSE OF THE STUDY

The purpose of the study is to investigate the effectiveness of transferring skills from an instructional program involving cognitive apprenticeship, a practical means of providing academic instruction to students with special learning needs, with a more traditional view of teaching fragmented and isolated skills. A cognitive apprenticeship

model focuses one's knowledge and skills on solving specific, real world problems, whereas more traditional methods of instruction tend to fragment and isolate small pieces of knowledge, and use calculations with specific isolated skills, which is similar to the type of information posed on traditional standardized tests.

RESEARCH QUESTIONS

Research has shown that learning disabled students are inefficient learners. These students have a unique way of processing information, exhibit inadequate and inflexible problem-solving strategies and their metacognitive processes operate differently (Meltzer, Solomon, Fenton, & Levine, 1989; Swanson, 1988, 1989; Torgesen, 1978; Wong, 1986).

1. Is it possible that students learning through cognitive apprenticeship might transfer and flexibly use advanced cognitive skills with greater proficiency than other students?

Special education analysts have also documented how the effective use of instructional time increases the achievement of students with mild educational disabilities (e.g., Greenwood, 1991; Leinhardt, Zigmond, & Cooley, 1981). Schoenfeld (1989) further claimed that a key goal in teaching these children was to develop teaching methods that helped students acquire and integrate cognitive and metacognitive strategies. These strategies would then enable them to use, manage, and discover knowledge.

2. Will students acquire, and be able to integrate cognitive and metacognitive strategies in a cognitive apprenticeship model incorporating a task performance project?

Impact of cognitive apprenticeship models on standardized test scores is uncertain since it focuses one's knowledge and skills on solving specific, real world problems. More

traditional methods of instruction tend to fragment and isolate small pieces of knowledge, similar to the types of information posed on standardized tests.

3. If the methods of more traditional instruction, which are more geared towards academic performance on standardized tests, are employed, how well could these students transfer and flexibly use advanced cognitive skills in an authentic situation?

THEORY

The *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) is a broad framework to guide reform in school mathematics in terms of content priority and emphasis. It discusses curricula and assessment criteria, but it does not explain how to bridge the gap between classroom assessment objectives and the use of the standardized test. If the classroom objectives are directly aligned with those of the standardized mathematics test, then no problem exists. However, many instances of misalignment occur between classroom assessment practice and standardized testing. Teachers, local schools, districts, and state education agencies still monitor pupil progress and mastery through standardized and formal multiple-choice or paper-and-pencil assessment tools, while promoting performance-based or alternative assessment procedures in the classroom with teachers who have had little or no training in assessment techniques. In balancing assessment strategies, Herman, Aschbacher and Winters (1992) stated that skills students exhibit in the assessment situation should transfer to other situations and other problems.

NEED

What is needed are serious efforts to reskill teachers, providing them not only with tools such as sample problems and scoring procedures, but with specific problem-solving strategies that can then be incorporated with performance-based assessments. This will enhance teachers' understanding of how students' performance on innovative multiple-

choice items relates to their performance in actual problem-solving situations, thus giving them the confidence to construct their own assessment instruments.

OVERVIEW

Chapter 2 involves a discussion of literature involving the philosophy and research surrounding performance-based assessment as well as specific strategies developed for teaching students at-risk and with learning disabilities. It will also include a comprehensive review on Grant Wiggins' Assessing Student Performance (1993). Design of the study will be completely explained in Chapter 3. A description of the sample, operational measures, testing hypotheses, design and analysis will be presented with a meaningful summary as a conclusion.

CHAPTER II

REVIEW OF THE LITERATURE

MATHEMATICAL ASSESSMENT

Recent literature on assessment in mathematics is abundant due to the advent of the Curriculum and Evaluation Standards for School Mathematics in 1989. The impetus for a pendulum swing from narrow conceptions of assessment, as paper-and-pencil tests that require students to produce an expected answer, to an assessment drawing on many methods to ascertain individual students' knowledge of mathematics has derived from a strong demand that students know mathematics. Byrne (1989) found that "Most American students leave school with such a poor understanding of mathematics that they cannot adequately perform the vast majority of jobs, much less consider specialized careers in mathematics or science" (p.597). Almost half of the over 3 million students who were high school juniors and seniors during the 1989-1990 school year finished school without mastering 8th-grade mathematics (Anrig & Lapointe, 1989).

The *Standards* make it very clear that assessment should be: integral to instruction; multiple assessment methods should be used; and all aspects of mathematical knowledge

and its connections to other branches of knowledge should be assessed. Webb (1993) defined assessment as the comprehensive explanation of a student's or group of students' knowledge. He further stated that assessment and its results should not be the end of instructional experiences; instead it should be a means to achieve educational goals.

Due to theories teachers are now finding themselves questioning their own belief systems both in the teaching of mathematics and in their expectations of students. This self-examination has developed from the confusion exemplified in the *Agenda for Action* of the National Council of Teachers of Mathematics (1980), which asks that "problem solving be the focus of school mathematics" (p. 1). Discussions of the teaching of problem solving have moved from advocating that students simply be presented with problems or with rules for solving particular problems to developing more general approaches to problem solving (Stanic, Kilpatrick, 1988). Problems in mathematics have been a primary theme since ancient times, but problem solving has not. Only recently have mathematics educators accepted the idea that the addition of problem solving ability is worthy of special attention. The term *problem solving*, however, has become a slogan encompassing different views of why we should teach mathematics in general and problem solving in particular (Stanic and Kilpatrick, 1988). There is no adequate clarification of what problem solving is or why we should teach it. Further complications involving problem solving lie in the topic of testing mathematical problem solving.

Silver and Kilpatrick (1989) discussed two functions that the testing of problem-solving performance serves - to provide information that teachers can use in making

instructional decisions and to signal to students, teachers, and the general public those aspects of learning that are valued. They further conclude that:

As long as test construction remains dominant by traditional views that put a premium on efficiency of measurement, including single scores for unidimensional measures having high internal consistency, problem solving will not be adequately assessed by tests. (P.182)

Recently efforts have been made to develop achievement tests which require students to recognize when problems have a similar mathematical structure or observe that a given mathematical model can be used to represent a problem. There have even been efforts to include open-ended problems for students to solve in which they generate numerous conjectures based on a set of given data or conditions. However, unfortunately a premium is placed on memory and on skill in manipulating numerical or algebraic expressions and does not allow for much reflection (Silver, Kilpatrick, 1989).

Silver and Kilpatrick (1989) recommend three directions for the future: refine our technique for assessing problem solving by continuing to develop current approaches to assessment; utilization of technology in which available technology of tailored testing permits each student to receive questions by computer that are suitable for his or her level of ability and allows the student to spend more time on each question with no loss in measurement efficiency; and reskilling teachers to conduct problem-solving lessons, assess how students respond to them and how their performance improved as a consequence.

Wiggins (1993) makes a clear distinction between an assessment and a test by defining an assessment as a comprehensive, multifaceted analysis of performance and an educational test as an "instrument," a measuring device used to elicit the kind of behavior we want to observe and measure. The role of responsiveness to individual test takers and contexts and human judgment are deliberately minimized, if not eliminated because a test

is an evaluation procedure in which the mechanization of scoring is accomplished by taking complex performances and dividing them into discrete, independent tasks that minimize the ambiguity of the result. "But the meaning of measurement requires assessment." (p. 13).

Unfortunately, recent attempts to control what teachers are doing in instruction have had the consequence of deskilling them-convincing them that they lack the expertise to assess how their students are learning and thinking (Silver, Kilpatrick, 1989). Many students have paid dearly for their teachers' expeditiousness and impatience with testing and grading - haste produced by school schedules that demand 128 final grades by the Monday after the Friday exam (Wiggins, 1993). Just because a student got it right on a multiple-choice assessment does not mean that the student understands the concept (Gay, Thomas, 1993). Silver and Kilpatrick (1989) summed up the refinement for assessing problem solving as "our need to understand how students' performance on innovative multiple-choice items, such as those assessing the ability to match a diagram with a problem or those asking students to judge the reasonableness of a solution, relates to their performance in actual problem-solving situations" (p.184).

Assessment requires the skills of a sensitive, informed teacher. Providing teachers with sample problems and scoring procedures is not enough. Assessment must be linked with the curriculum and instruction based on contemporary theories of learning and cognition. Herman, Aschbacher, and Winters (1992) provide the following issues concerning assessment:

1. Assessment must be congruent with significant instructional goals.
2. Assessment must involve the examination of the processes as well as the products of learning.
3. Performance-based activities do not constitute assessment per se.

4. Cognitive learning theory and its constructivist approach to knowledge acquisition supports the need to integrate assessment methodologies with instructional outcomes and curriculum content.
5. An integrated and active view of student learning requires the assessment of holistic and complex performance.
6. Assessment design is dependent on assessment purpose; grading and monitoring student progress are distinct from diagnosis and improvement.
7. The key to effective assessment is the match between the task and the intended student outcome.
8. The criteria used to evaluate student performance are critical: in the absence of criteria, assessment remains an isolated and episodic activity.
9. Quality assessment provides substantive data for making informed decisions about student learning.
10. Assessment systems that provide the most comprehensive feedback on student growth include multiple measures taken over time (pp. V-vi).

The National Council of Teachers of Mathematics feels that authentic assessments tasks highlight the usefulness of mathematical thinking and bridge the gap between school and real mathematics. The fundamental issue is how to estimate what a person knows from a small sample of his or her behavior (Marshall, 1989).

New assessments stress the importance of examining the processes as well as the products of learning. They encourage the student to move beyond the "one right answer" mentality and challenge students to explore the possibilities inherent in open-minded, complex problems, and to draw their own inferences (Herman, Aschbacher, Winters, 1992). Three aspects of evaluation seem predominant from an evaluation (Marshall, 1989): (a) We need to know whether the individual has enough facts about the domain-specific details that must be acquired before an individual can engage in problem solving. In mathematics, these are facts and concepts such as addition facts, multiplication facts, and knowledge of the order of operations. (b) We need to know that the individual has the requisite behavioral alternatives or procedural knowledge characterized as a set of rules that can be applied to a situation whenever specific conditions are satisfied. In arithmetic, the algorithms for carrying out arithmetic operations are good examples. (c) We want to

know whether the individual can call upon the knowledge and skills in a non-predetermined order to make sense of a new experience. Such knowledge resides in a schema, being able to relate aspect (a) to aspect (b).

INTEGRATING LEARNING WITH INSTRUCTION

Learning is more than just gaining meaning, applying, and communicating mathematics. Learning mathematics includes cognition, metacognition and affect (Herman, Aschbacher, Winter, 1992). Since a great deal of emphasis in mathematics has been on "problem solving", much of the more recent research in mathematics has been conducted by cognitive psychologists, who seek to develop and validate theories of human learning and problem solving and mathematics educators, who seek to understand the nature of the cognitive interaction between students and the mathematical subject matter they study and the problems they solve (Silver, 1987). Schoenfeld (1992) defines learning to think mathematically as developing mathematical points of view and having the capacity to apply them and developing competence with mathematical sense-making; that is abstraction, symbolic representation, and symbolic manipulation.

Recent research has shown that learning disabled students are inefficient learners. These students have a unique way of processing information, exhibit inadequate and inflexible problem-solving strategies and their metacognitive processes operate differently (Meltzer, Solomon, Fenton, & Levine, 1989; Swanson, 1988, 1989; Torgesen, 1978; Wong, 1986). For these reasons, there characteristically is a discrepancy between the student's learning potential and performance in mathematics. Learning disabled students

are unable to use critical thinking without specific training. Some have visual perception difficulties that preclude seeing accurately what is presented to them, and still others have poor retention or auditorially, they misperceive words or parts of words (Bley & Thornton, 1989). Therefore, Schoenfeld (1989) claimed the focus in teaching these children was to develop teaching methods that helped students acquire and integrate cognitive and metacognitive strategies. These strategies would then enable them to use, manage, and discover knowledge.

Peterson (1982) agreed that an understanding of differences between students and their cognitive processes was necessary for developing teaching methods that considered those differences. Her (1982) mathematical study on probability with 72 fifth and sixth grade students was based on direct instruction teaching. Student attendance, understanding and use of cognitive strategies, were measured using subscales. The data revealed that higher ability students attended, understood and used cognitive strategies to a greater degree than lower ability students. These results indicated that ability was positively related to achievement, and that cognitive processes are associated to both ability and achievement. Peterson's (1982) study clearly supported Brown (1978) who contended that one must be able to monitor their own understanding of instruction in order to learn. This pre-requisite required that the student have a recognition of skills, strategies, and resources needed to accomplish a problem and the innate qualities to use self-regulated mechanisms to complete the problem (Mercer, 1992). These metacognizant strategies do not occur in a learning disabled student until higher executive processes have been addressed (Borkowski, Estranda, Milstead, & Hale, 1989).

Riley's (1989) study utilizing the Mathematics Achievement subtest of Peabody Individual Achievement Test (Dunn, Markwardt, 1970) and the Inventory of Piaget's Developmental Tasks (Furth, 1970), found that mathematical achievement significantly correlated with cognitive ability. These findings were also consistent with research attesting to a developmental delay in the selective attention ability of children with learning disabilities. Furthermore, Peterson (1982) found that students with higher level cognitive abilities were able to succeed on a variety of academic tasks, used a variety of specific cognitive strategies, related prior knowledge to problem-solving, had insight about material and recognized the teacher overview that promoted understanding. Lower ability students provided only general or imprecise reasons for the manner in which they completed the tasks. This was further supported by Swanson's (1989) view that learning disabled students display inefficient strategies in performing complex academic tasks and, therefore, cannot perform at a level in which they are intellectually capable. Swanson (1989) further suggests that learning disabled students do not process the organizational aspect of information in the same way as normal achievers.

Current cognitive research has focused on teacher expertise as a critical factor in helping students to use cognitive and metacognitive strategies in problem-solving (Schoenfeld, 1985). According to Schoenfeld (1992), goals for mathematical instruction rely on one's interpretation of what mathematics is, and the definition of understanding mathematics. He described a curriculum based on mastery of a body of mathematical facts and procedures as extremely poor. To progress in mathematics, one must have the capability of making and recognizing associations, comprehend basic relationships, make

generalizations, and understand as well as apply mathematical concepts and methods (Schoenfeld, 1989). The learning of procedural knowledge comprises a significant part of mathematical learning. It cannot be explained as learning a sequence of mechanical steps, but rather as a procedural knowledge that is built on a foundation of schematic knowledge (Resnick, Neches, 1984). Schemata are useful for retrieving clusters of related and useful information as well as setting up the problem (Silver, 1987). Usage of the schema allows solvers to develop an initial mental representation of the problem. This representation changes as it interacts with other information until an adequate answer has been obtained. Silver (1987) concludes that the quality of the solver's representation is seen as central to the problem-solving process. Math educators now realize through cognitive studies, that learning is a slow, constructive process in which a portion of one method gradually becomes integrated in a mastered skill (Nesher, 1986).

Schoenfeld (1985) supports Nesher's concepts with his implementation of mathematical problem-solving procedures with college students. His theory of expertise being the ability to carry out complex problem-solving tasks in a domain, led him to design a methodology of teaching students that mathematics consists of applying problem-solving procedures, reasoning and managing problems. This was to be accomplished through the use of heuristics, control strategies, and beliefs. Schoenfeld (1985), employed the elements of modeling, coaching, and scaffolding, which ultimately led to fading, as activities highlighting cognitive processes and knowledge structures necessary for expertise.

Schoenfeld (1985) believed students should first be presented with a complete example of solving a problem from beginning to end in his modeling element. This

technique allowed him to present and model new heuristics, “rule of thumb”, in problems. Through coaching, Schoenfeld acted as moderator requesting heuristics and solution techniques from students while demonstrating control strategies for making judgments about how best to proceed. Scaffolding provided the support in managing the direction in which course to pursue. Schoenfeld (1985) was careful in sequencing the problems so that he achieved motivation, amplification, practice, and integration. More in-depth discussion of the cognitive apprenticeship model is included in Section 4 of this chapter.

Meltzer (1989) utilized similar problem-solving techniques in analyzing academic performance of learning disabled students. Using criterion-referenced, process-based, problem-solving tasks, a collection of diagnostic information on processes as well as the content of learning was developed. The measurements included categorization, concept formation, pattern analysis, flexibility in shifting strategies, and sequential reasoning. Her study in the math area led to sub-typing based on the academic achievement involved, age-level of the child, and whether the child was learning disabled or a normal achiever. Meltzer (1989) further concluded that LDs may manifest different disabilities as they progress through school. Therefore, there is a need to broaden the scope of subtype research toward a multidimensional approach incorporating problem-solving and metacognitive strategies.

Mere acquisition of knowledge and skills does not make students into competent thinkers or problem solvers. They must also acquire the disposition to use the skills and strategies and know when to apply them. Caine and Caine (1991) believe that the transfer of skills and concepts from one situation to another is enhanced when instructional

activities are organized to appeal to learners' emotional needs for relevance and meaning. When learning is valued, it is more likely to be retained and transferred to other circumstances (Bransford, Hasselbring, Kinzer, & Williams, 1990). Increasingly modern life requires students to have problem-solving, critical thinking, decision-making, and reasoning abilities (Resnick, 1987). To address these needs, educators must empower all students with the ability to acquire, transfer, and apply higher order cognitive skills in a variety of settings (Rojewski, & Schell, 1994). Many secondary school curricula have been reorganized to emphasize advanced cognitive skill development. However, Means and Knapp (1991) have pointed out that students with special learning needs typically have the least access to educational opportunities that would help them develop these skills.

If knowledge has no apparent application, it may not be perceived as meaningful; it is thus not likely to be transferred to other learning experiences (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990). This scenario may be especially true for youth with special needs, who often take longer, require repeated exposure, and benefit most from concrete experience during the learning process (Hardman, Drew, Egan, & Wolf, 1990). Brown, Collins, and Duguid, (1989a) viewed advanced cognitive skills as mental tools that could be used to accomplish meaningful activities. Their idea of authentic activity involves using the ordinary practices of a given culture as a basis for learning. Through authentic experiences students pick up mathematics by internalizing it, that is, by living in a culture in which the appropriate values are reflected in the everyday practices of the culture (Schoenfeld, 1989). Students need to learn mathematics in classrooms which are little worlds of mathematical culture, classrooms in which the values of mathematics as

sense-making are reflected in everyday practice. Every instructional activity is an assessment opportunity for the teacher as well as a learning opportunity for the student.

RETHINKING ASSESSMENT

Assessment has not only become the focus of our nation's current educational reform agenda, but it is a major driving force behind curriculum and instruction where standardized testing (i.e., achievement tests, EWT, HSPT) are determined to give insight into general program effectiveness at the classroom, local school district, and overall state level. Student outcomes on these tests determine the important goals of classroom instruction since the validity, fairness and usefulness of a test depends on the content match of knowledge, skills, and dispositions that teachers are teaching and those that students are expected to learn or acquire. School administrators and district planners use these results in order to determine program effectiveness, areas of curricular strength and weakness as well as for topics of staff development, materials needs, and for targeting and assessing plans for improvement. Marshall (1989) contends that achievement tests provide little or no diagnostic information and do not measure a sufficient range of concepts to be of value as assessment tests.

Cooney, Badger, and Wilson (1993) do not believe that it is possible to bridge the gap between new forms of assessment reflecting different and more fundamental visions of what it means to know mathematics. They claim that as long as mathematics is viewed as consisting primarily of a series of steps to be applied in isolated contexts, teachers will

view moves toward alternative methods of assessment as peripheral to the "real curriculum." Herman, Aschbacher, and Winters (1992), however, feel that new visions of effective curriculum, instruction, and learning demand new attention to systematic assessment. Educational and societal trends support these new visions of teaching and learning to such an extent that unprecedented demands have been placed on teachers' professional skills requiring them to integrate knowledge of intended goals, learning processes, curriculum content, and assessment.

Wiggins (1993) has gone to the root of the problem in bridging the gap in linking assessment to instruction. He feels that assessment, to be educational and fair, needs more a matter of principle and less a matter of good intentions, mere habit, or personality. He agrees with Feuer, Fulton, and Morrison (1993) when they argue that the Congress should "require or encourage school districts to develop and publish a testing policy" (p.532). If each school district, at the very least, would develop an Assessment Bill of Rights to protect the inherently vulnerable student from the harms that testing easily leads to, a local procedure for ensuring that assessment practices of both students and educators would be publicly scrutinized, discussed, justified, and improved (Wiggins, 1993). "We must determine the aim of education before we can determine what we should assess and what kind of evidence we should seek" (p.35). A thoughtful assessment system does not seek correct answers only, judgment must be seen to be an essential element of assessment: mere right answers to uniform questions are incapable of revealing its presence or absence. The skills that students exhibit in the assessment situation should transfer to other situations and other problems (Herman, Aschbacher, & Winters, 1992).

Reskilling teachers to understand that what must be assessed is not whether the student is learned or ignorant but whether he or she is thoughtful or thoughtless about what has been learned is an inescapable moral dilemma to all learning (Wiggins, 1993). Wiggins elaborates on the aim of maximizing everyone's achievement, but teachers cannot imagine doing so without lowering or compromising their standards. Herman, Aschbacher, and Winters (1992) add to this dilemma the concept that there is no one right way to assess students. They claim that a balanced curriculum requires a balanced approach to assessment and the need for a reliable scoring scheme. Knowing how to proceed with assessment development calls for supporting instructional improvement, balancing assessment strategies and holding assessments to high standards.

LINKING ASSESSMENT AND INSTRUCTION

"Thinking Curriculum" by Lauren Resnick and Leopold Klopfer (1989) is a modern approach to curriculum advocating an integrated, active view of student learning. It stresses the importance of process as well as product. Students are involved in tasks similar to those encountered in the real world, solving problems, making decisions, constructing arguments, and so forth. In this way, they model the process of a professional discipline while acquiring knowledge in that discipline. Much recent discussion about the goals of mathematics learning has focused on the development of the understanding of mathematical concepts involving more than mere recall of definitions and recognition of common examples (National Research Council 1989; NCTM 1989). "Tasks that ask

students to apply information about a given concept in novel situations provide strong evidence of their knowledge and understanding of that concept" (NCTM, 1989, p.223).

Although conceptual understanding is clearly one of the major goals of mathematics teaching, students' capacity for applying, communicating, and integrating their mathematical understandings is also important. Furthermore it is important to assess students' confidence, interest, curiosity, and inventiveness in working with mathematical ideas (NCTM, 1989). It is not only important to worry about what the student knows, but whether what they know has any meaning (Wiggins, 1992). In mathematics, a thinking curriculum helps students acquire the key concepts and tools for making, using, and communicating knowledge in a specific field. "Working knowledge of the field implies an integrated network of knowledge and concepts rather than a collection of isolated facts" (Herman, Aschbacher, Winters, 1992, p.17). Thus assessment:

"must be an interaction between teacher and students, with the teacher continually seeking to understand what a student can do and how a student is able to do it and then using this information to guide instruction" (Webb and Briars, 1990, p. 108).

Issues related to learning transfer, situated learning, and expert/novice approaches to learning and problem solving are key to the development of advanced cognitive skills in students with special needs (Rojewski & Schell, 1994). To measure student achievement, assessment must be congruent with significant instructional goals. It must involve the examination of the processes as well as the products of learning. The key to effective assessment is the match between the task and the intended student outcome. Assessment systems that provide the most comprehensive feedback on student growth include multiple measures taken over time.

Corn, in her 1989 book Teaching Remedial Mathematics to Students with Learning Disabilities, cited the following characteristics of college students with LD: impulsivity, poor note-taking skills, poor study skills, poor memory, passive learning style, and poor strategies for monitoring errors. The Cognitive Apprenticeship technique employs elements of activating information for use in multiple contexts, situating learning in real world activities, and provides models of expert performance which offers significant promise for encouraging learning among individuals with special needs (Berryman, 1991; Collins et al., 1991; Resnick, 1987). Cognitive apprenticeship stresses symbolic, mental (thinking) skills taught in combination with physical skills. Here, internalized mental processes are externalize through social interaction, observation, practice and reflection about tasks to be completed (Brown et al., 1989a; Means & Knapp, 1991). Collins et al. (1991) noted that cognitive apprenticeships utilize authentic tasks in meaningful environments and purposively sequence tasks to reflect changing demands of learning, and a strong emphasis is placed on generalizing knowledge to a wide variety of settings.

The first step in assessment design or selection is to know the purpose of your assessment. Authentic assessments are constructed around outcome goals therefore dependent upon designing the tasks backwards (Wiggins, 1994). Because performance assessments require considerable time and energy, Wiggins (Class, 1994, p. 2) lists the following assessment reform principles to be used during a task performance project:

1. Assessment should improve performance, not just monitor it.
2. Assessment should never be reduced to testing.
3. Assessment is valid and reliable judging in reference to criteria and standards, not mere collecting or casual observing of student work.
4. Progress does not equal growth; Standards do not equal local expectation norms
5. "Form" follows "function" in healthy organizations. "Forms" are the structures, rules, and regulations that support the "function" or objectives. Schedules in particular, should be reviewed in light of assessment needs.

6. Know your institutional "customer(s)" – the next level(s) above you -- and inform your standard-setting by their standards" (Class, 5/94).

Just as performance task projects, cognitive apprenticeship allows students of all ability levels to interact and learn in the same environments. The cognitive apprenticeship model is developed around four main elements – content, methods, sequence, and sociology (Collins et al., 1991). These four components capitalize on knowledge of transfer, situated learning environments, and the use of expert approaches to problem solving. The teacher's role is to mediate or facilitate learning among active rather than passive participants (Rojewski, & Schell, 1994). When cognitive apprenticeship methods are combined with other teaching techniques, such as direct and explicit instruction, an entire range of instructional strategies that promote the development of problem-solving strategies is encouraged (Gersten & Carnine, 1986; Palincsar & Brown, 1984; Pearson & Raphael, 1990).

A key goal in the design of teaching methods should be to help students to acquire and integrate cognitive and metacognitive strategies for using, managing, and discovering knowledge. Elements of observation and guided practice methods consist of modeling, coaching, scaffolding, and fading. Schoenfeld (1983, 1985) utilized these practices in a variety of activities designed to highlight different aspects of the cognitive processes and knowledge structures required for expertise. His modeling of mathematical problems embraced context-based observation of an expert performing a task. Students could observe the use and management of specific heuristics (rule of thumb for how to approach a given problem) and control strategies used by the expert. While coaching students emulating more complex expert behaviors, he would offer hints, provide support and

feedback, design opportunities for additional modeling, or give prompts and reminders. All coaching methods are aimed at bringing the learner closer to expert behavior. Schoenfeld used scaffolding as an instructional method that relied prominently on dialogue between teacher and student to help a student successfully carry out a task. These supporting questions or direct interventions provide learners with just enough support and guidance to achieve goals that are beyond their unassisted efforts. As students become more competent, Schoenfeld would fade allowing learners to act increasingly more on their own.

Cognitive apprenticeship models seem to be especially well suited for incorporating a diverse array of students with varying capabilities. It accommodates both low and high-achieving students working together. When determining priority outcomes in alternative assessment projects it is important to determine what cognitive and metacognitive skill development is desired as well as social and affective skills. Statements of types of problems students should be able to solve and the concepts and principles they are to be able to apply should also be considered when developing outcome goals (Herman, et al., 1992).

SUMMARY

The Curriculum and Evaluations Standards for School Mathematics published by the National Council of Teachers of Mathematics in 1989 created an impetus for changing assessment procedures in mathematics throughout the nation. The premise that students

will be using mathematics in a world where calculators, computer, and other forms of technology are readily available; where mathematics as a field of knowledge is rapidly changing; and where mathematics is continually being applied to more fields of work and study, created a demand that students know mathematics and be able to use mathematics in the changeable world that these students will face during their lifetime. Byrne (1989) found, "Most American students leave school with such a poor understanding of mathematics that they cannot adequately perform the vast majority of jobs, much less consider specialized careers in mathematics or science" (p.597). Almost half of the over 3 million students who were high school juniors and seniors during the 1989-1990 school year finished school without mastering 8th-grade mathematics (Anrig & Lapointe, 1989).

These deficiencies in the general population are crucial, but the continuing failure of students with mild disabilities to master basic skills math can be characterized as outrageous. Making matters worse, the investigation and remediation of mathematics performance deficiencies among students with learning disabilities have not received the same level of attention as other areas, such as reading and language (Bender, 1992). Students with special learning needs typically have the least access to educational opportunities that would help them develop skills of acquiring, transferring, and applying higher order cognitive skills in a variety of settings (Means & Knapp, 1991).

Recent research has shown that learning disabled students are inefficient learners. The students have a unique way of processing information, exhibit inadequate and inflexible problem-solving strategies and their metacognitive processes operate differently (Meltzer, Solomon, Fenton, & Levine, 1989; Swanson, 1988, 1989; Torgesen, 1978;

Wong, 1986). Learning disabled students are unable to use critical thinking without specific training. Some have visual perception difficulties that preclude seeing accurately what is presented to them, and others have poor retention or auditorially, they misperceive words or parts of words (Bley & Thornton, 1989). Therefore, Schoenfeld (1989) claimed that the focus in teaching these children was to develop teaching methods that helped students acquire and integrate cognitive and metacognitive strategies. These strategies would then enable them to use, manage, and discover knowledge.

The *Standards* call for assessment to be conducted with multiple measures and well-chosen tasks affording teachers the opportunities to learn about their students' understandings. Alternative assessments and performance tasks are being widely researched and being promoted as appealing ways to assess complex thinking and problem solving because they are grounded in realistic problem situations. It seems that learners benefit from having ample opportunities to use newly acquired information and experience its effects on their own performance (Bransford & Vye, 1989). If knowledge has no apparent application, it may not be perceived as meaningful; it is thus not likely to be transferred to other learning situations (Bransford et al., 1990). This scenario may be especially true for youth with special needs, who often take longer, require repeated exposure, and benefit most from concrete experience during the learning process (Hardman et al., 1990).

Cognitive apprenticeship emphasizes a combination of authentic problem-solving experiences with expert guidance in lieu of decontextualized instruction (Schoenfeld, 1985). Just as performance task projects, cognitive apprenticeship allows students of all

ability levels to interact and learn in the same environments. The cognitive apprenticeship model is developed around four main elements - content, methods, sequence, and sociology (Collins et al., 1991). These four components capitalize on knowledge of transfer, situated learning environments, and the use of expert approaches to problem solving. Cognitive apprenticeship models seem to be especially well suited for incorporating a diverse array of students with varying capabilities. It accommodates both low and high-achieving students working together.

Learning conducted in real life contexts using authentic activity increases the relevance of knowledge and provides learners with concrete application of abstract ideas and knowledge. The goal directedness of cognitive apprenticeship should also enhance student motivation for finding out the answers to their questions (Caine & Caine, 1991). The role of the teacher in a cognitive apprenticeship model is to facilitate and mediate student learning.

CHAPTER III

DESIGN OF THE STUDY

STATEMENT OF THE PROBLEM

Most Americans leave school with such a poor understanding of mathematics that they cannot adequately perform the vast majority of jobs. During the period of 1989-1990 over 3 million junior and senior students finished school without mastering 8th-grade mathematics (Anrig & Lapointe, 1989). These deficiencies in the general education population are crucial, but the continuing failure of students with mild disabilities to master basic skills math can be characterized as outrageous. Little investigation and remediation of mathematics performance deficiencies among students with learning disabilities has been conducted.

RESEARCH QUESTION

The primary research question is whether students exposed to research based teaching techniques involving manipulatives and performance assessment, can transfer and flexibly use cognitive skills in a more formal assessment. An extension of this question is whether students taught with more traditional techniques, focusing on sequences of

mechanical steps applied in isolated contexts, can transfer and flexibly use advanced cognitive skills in an authentic situation.

SUBJECTS OF THE STUDY

The subjects of this study were 27 seventh-grade children, 11 specifically assigned to Basic Skills Instruction (BSI) in mathematics and 16 who were in BSI mathematics last year, but were not assigned BSI this year due to their scores being marginally above the BSI cut off. They are, however, benefiting from in-class support since 6 of the 16 are eligible for Special Education.

Each of the students eligible for Special Education have special needs requiring modifications within the mathematics program. They all share organizational problems as well as auditory processing disabilities. They need to have concepts simplified, repeated, and time to process. Notetaking is extremely difficult and each has reading deficits. Six other students are in the English as a Second Language (ESL) program. They have minimal abilities to speak, understand, and write English. The rest of the class consists of students who marginally missed BSI services and have behavioral problems

The students were selected because of their history of mathematical difficulties resulting in continual assignment to remedial math classes utilizing traditional mathematical teaching techniques.

PROCEDURES

A criterion-referenced, assessment instrument focusing on basic skills arithmetic and fractions was constructed and administered to the students. The design of the instrument was a hierarchical format requiring students to apply information about a given concept and make a multiple-choice response. This same formal assessment was used at the end of the study to compare not only individual progress, but group progress as well.

A comparison of the scores should indicate one of two things: differences in teaching styles and techniques have a definite influence on students' abilities to learn or they have little to no effect on students' abilities to perform on criterion-referenced tests. If there are significant indications from the criterion-referenced assessment that one group out performs the other group, then a reasonable conclusion would be that the teacher's style and techniques did have an effect and would be a more desirable way to educate children. If, however, the results were not significant, indicating styles and techniques did not have an impact, then a reasonable conclusion would be to use instructional techniques that have been researched based as previously described in this paper.

The students assigned to the BSI classes are being taught through traditional teaching techniques utilizing paper and pencil tasks and focusing on mechanical steps applied in isolated contexts. A very structured textbook provides the students with multiple isolated skills in a "drill and kill" format with examples provided in a rote memorization style for each lesson. Problem solving consists of traditional word problems using one step computation. A standardized multiple-choice assessment is conducted at the end of each chapter.

Students do not use manipulatives nor are they provided with visual models other than drawing on the board or on a transparency. A typical class period consists of a review of homework, the lesson as provided by the book, and a related homework assignment which is also from the book. The students have had an opportunity to use the computer lab.

The students being assisted by in-class support are receiving instruction based on recent research. Instructional strategies involve comprehensive efforts to provide metacognitive skills, experiences ranging from the concrete to the semi-concrete to the abstract levels, and authentic assessments which examine the processes as well as the products of learning.

Based on research validated approaches, a task performance project was designed to make the students active learners rather than passive learners. Included within this project an effort was made to provide metacognitive skills through several techniques. The first was based on the belief that students need to utilize their textbooks as a learning tool. The text provides vocabulary and examples pertinent to concepts being taught but students are unable to utilize their books in a beneficial manner. A prevalent problem of reading levels and the inability to transfer concepts from one example to another problem-solving situation prompted the idea to transform the classroom into a living textbook.

The walls are covered with "Language of Math" vocabulary while examples of problem-solving are clearly demonstrated on large posters and visible from any part of the room. A continuous emphasis is placed on developing patterns by matching problems to examples on the wall that represent a similar problem-solving method. Vocabulary is given

meaning by using it continually. Students are encouraged to use proper mathematical terms by referring to the wall for necessary words and examples. The use of common mathematical terms in a formal manner is emphasized through a "Do Now" activity at the beginning of class. Finally a comparison of the textbook to the room is stressed with each lesson and generalizations of using examples to problem-solve are modeled and coached.

The designed task performance project, *Games - Recycled Math*, focuses on students using prior knowledge and skills to solve a real world problem: planning, designing and constructing a mathematical game (See Appendix A). The purpose was to have the students explore the many problem-solving activities within a game. Thoughtfully evaluate and accurately analyze elements of diversity in games. Imaginatively and thoroughly establish principles of a game involving fractions, and communicate the game idea and design in a written and oral format. Each student was provided with a study guide to not only help them with solving the problem, but as an assessment tool to measure their understanding of the problem (See Appendix B). In order for the students to realize the importance of the study guides, they were given an evaluation sheet indicating the point value leading to a final grade in each phase of the project (See Appendix C).

In a cooperative setting students were provided with study guides to enable them to become expert problem solvers. Each study guide was designed to teach *learning-to-learn* skills necessary for more complex skills of metacognition. The task was divided into two sections: Phase I involving analysis of games and Phase II - construction of their original game. Initially the project consumed two days of the week with the other three

being devoted to concept development concerning fractions, but as the project advanced it consumed three days.

The students were introduced to the project through a presentation of homemade games. Five games were made from old game boards or left over materials from around the house (See Appendix D). The students were led in a discussion as to the types of mathematical concepts possibly involved within each game. This led to further discussion regarding rules necessary to play the games. Students then examined the games and concentrated on the materials that had been used to make them.

Since the project was extensive, each study guide was color-coded, and the formal copy to be turned in, was printed on the specified color paper so it could be easily identified by the students thus emphasizing and modeling an organizational strategy. Students were provided the ability to brainstorm using a study guide printed on white paper with a color reference and then, as a group, select the best ideas and present them on the formal colored copy. At the conclusion of each class students were requested to complete an index card describing their personal contribution and an evaluation of whether they liked or disliked and activity with an explanation as to why.

Study guide-1A emphasized a connection between mathematics and games by involving students in the exploration of problem-solving activities within games. Each group was given a packet with several games depicted in an advertisement format. The pictures and advertisements were cut from catalogues and arranged so that the students would have to examine the pictures as well as the brief summaries to determine what mathematical concepts were involved with each game. The study guide divided the task

into four sections: selection of games to examine mathematical concepts used; selection and reasons for purchasing any one of the games; determining whether the game was one of chance or skill; and describing the construction of the game, (i.e. mazes, cards, board game, etc.).

Study Guide-1B involved students with the task of finding patterns and recognizing the relationship of rules to games. In this lesson students were again provided with a packet containing rules from various games. The students were aided by a study guide and were expected to determine if a pattern was used in the development of rules (i.e., objective, equipment, how to play, etc.). They then rated the rules based on a 1-4 level of reading difficulty and were expected to give an explanation for their decisions. Finally the students were to examine the homemade games set up around the room and determine a name as well as an objective for the game.

Students were involved in developing objectives in Study Guide 1C. As they once again examined the homemade games, they were to determine what the objective might be for each one and then give each game a name.

Study Guide 1D concentrated on writing rules. Based on the previous lesson, students listed five important sections that should be included in rules. They then selected one of the homemade gameboard and pawns and developed a set of rules for the game. Emphasis was on constructing rules related to mathematical concepts.

Study Guide 1E allowed the group to design their own game. The study guide once more broke the task down. Beginning with the development of an objective, the

students made decisions on whether the game would be one of chance or skill, and the materials necessary to construct the game. This section concluded Phase I.

Phase II of the project focused on problem-solving involving financial decisions pertinent to the construction of the students' game. Study guides were used once again as well as information sheets. An evaluation sheet was again distributed prior to beginning Phase II providing the students with the point value of each activity (See Appendix E). In an attempt to create a real world problem solving situation involving a business aspect of constructing a game, the students formed companies and were challenged to purchase materials for building their games and required to make a video commercial as well as prepare a newspaper ad within a specific budget.

From an earlier project involving cash, students combined their money within their individualized groups to develop a cash flow. Each company was then given a credit card with a five hundred dollar credit line. The terms and agreements of the card allowed the students to earn credit towards payment through successful academic activities, i.e., 92 or above on a test, all homework turned in, maintaining a budget, etc. A final financial consideration presented to the students was for them to calculate their salaries based on five dollars and fifteen cents per hour during the construction of the game.

Phase II began after the winter holidays, therefore, in an effort to review, the students were required to write a summary, on Study Guide 2A, of their games which included the ages and number of players, equipment, objective of the game, how to play and how to win. This was a preliminary description of their games and was subject to change as their games developed.

Study Guide-2B aided the students in developing a budget. A price list was distributed to each group describing particular items and their cost. The study guide emphasized estimating the costs of their materials as well as selecting the length of their video and the size of their newspaper ad. The final section of the study guide required the students to delegate jobs and list each person's responsibilities. A technique used to model this task was based on a story created depicting a group's decision on how each person could contribute to obtaining the goal of building a mathematical game.

Through the story, purchase orders were introduced and samples were provided on an overhead projector. Parts of the purchase order were missing such as quantity of items, partial descriptions and the lack of a subtotal, sales tax, and total. A thorough discussion involved financial decisions made by the group in the story and the delegation of assignments and responsibilities by the members of this fictitious group.

Instructions were presented on easel paper tacked to the blackboard. The students were provided with real ledger cards for maintaining their budgets since computers were unavailable. They received real time cards to keep track of salaries and real purchase orders and receipts which would be submitted. At the end of seven days, the students conducted a Pay Day. Using Study Guide 2C, each individual calculated the others' salary.

With all things in place, the students were given an opportunity to purchase their materials from a table displaying everything from boards, to paint, markers and crayons. In a cooperative setting, they discussed materials needed, substitutes for items and prepared an individual rough purchase order on a practice copy. Some of the skills involved during this task included measuring, finding perimeter and area, determining unit rates,

percentages, and all operations. The students used calculators, yard sticks and rulers, and a variety of tools. Once the real purchase order was turned in, the students began constructing their games.

Since the game was focused on fractions, a final study guide was developed with specific criteria in developing problem-solving cards. Five categories based on the 5-8 concept development with fractions were selected from the *Standards*. Suggestions for collecting types of problems described were listed as well as how to use the textbook for selecting problem-solving ideas related to fractions.

Individual assessment of each study guide was conducted through several methods. First was an observational checklist determining three levels of applying strategies, concepts, and procedures logically: not understanding, developing, and understanding and applying. Each of those levels were subdivided into specific and individual objectives (i.e., makes no attempt; uses strategy if told; or generates new procedures, etc.). A second method was to administer a criterion-referenced assessment after each study guide had been reviewed and discussed (See Appendix F). A third method was conducted through transfer of concepts from the project to direct instruction of fractions, decimals and percentages, thus administering criterion-referenced assessments involving free response or multiple choices. Each problem was assessed on a 5 point scale ranging from 0, indicating no response to the problem, to 5, indicating the student completed the problem correctly and showed or explained it fully.

Chapter IV

Analysis of the Data

The major purpose of the study was to determine if seventh grade basic skills and special education students who experienced different teaching strategies and techniques would demonstrate an increased ability to solve problems on a criterion-referenced test. The sample for this study was restricted to 27 seventh grade students, 11 specifically assigned to Basic Skills Instruction (BSI) in mathematics and 16 who were either in BSI last year, or were eligible for special education services.

The two groups participating in the study included BSI students serving as the control group, and students receiving special services composing the experimental group. Both groups took the same criterion referenced pretest in November. Neither group was permitted to use calculators since they are not allowed to be used on the California Achievement Test which is given in April of each year.

For the period November 1994 through March 1995, the students in the experimental group were presented math concepts through an authentic problem-solving experience described in Chapter 3. The students in the control group were taught through traditional teaching techniques utilizing a standard math text, paper and pencil tasks and focusing on mechanical steps applied in isolated contexts. During the early part of March, the end of the instructional period, the students were once again given the criterion-referenced test.

Hypothesis:

1) There will be no significant difference in the achievement levels of problem solving abilities between those seventh grade basic skills students being taught through traditional teaching techniques and those students learning through an authentic problem-solving experience.

A t-test for the difference between the means of two populations was performed. The difference between the control group's pretest and post test scores was compared to the difference between the experimental group's pretest and post test scores.

The results indicate that the null hypothesis should be accepted. The t-statistic obtained from the control sample was -2.657 with 10 degrees of freedom while a t-statistic of -2.504 with 15 degrees of freedom was obtained from the experimental group. These numbers are less than 2.764 ratio need for the control group and 2.602 needed for the experimental group to reject the null hypothesis with .01 level of significance. The results are shown in Table 1.

Figures 1 and 2 following Table 1 represent the results of the pretest and post tests viewed as percentages.

Table 1

Peterson's Criterion-Referenced Test						
Number	Control Group			Experimental Group		
	Pretest	Post Test	Difference	Pretest	Post Test	Difference
1	14	19	5	23	22	-1
2	8	11	3	4	12	8
3	12	12	0	10	10	0
4	12	12	0	3	12	9
5	10	17	7	18	17	-1
6	16	11	-5	8	9	1
7	8	12	4	13	11	-2
8	11	20	9	8	17	9
9	17	20	3	14	18	4
10	12	14	2	5	13	8
11	7	13	6	15	16	1
12				9	8	-1
13				11	11	0
14				11	8	-3
15				9	14	5
16				5	10	5
Summary						
	Pretest	Post Test	Difference	Pretest	Post Test	Difference
Mean	11.545	14.636	3.091	10.375	13.000	2.625
Stan Dev	3.236	3.641	3.859	5.340	4.017	4.193
t Statistic	-2.657			-2.504		
Degrees of Freedom	10			15		

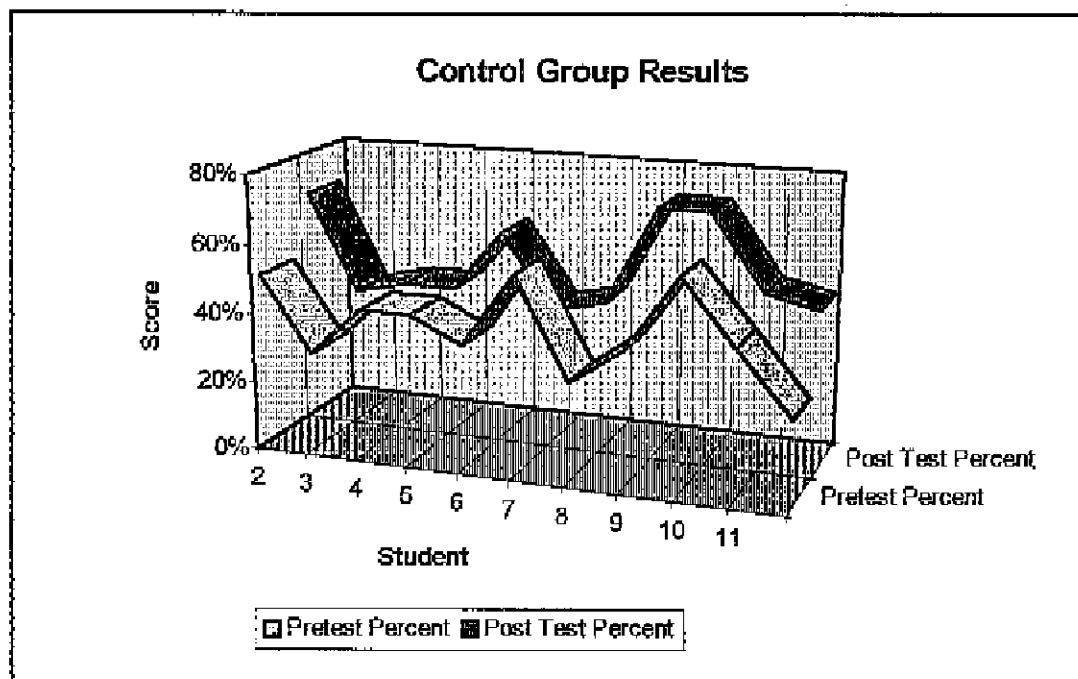


Figure 1

Figure 1 clearly indicates that 73% of the students in the Control Group increased their scores, 9% decreased, and 18% had no change. Of the students who increased their scores, one student demonstrated a 32% increase while two others demonstrated a 25% and a 21% increase. Three students had between a 10% and 20% increase and the other two were below a 10% increase. Three students did not change in their scores and only one had an 18% decrease.

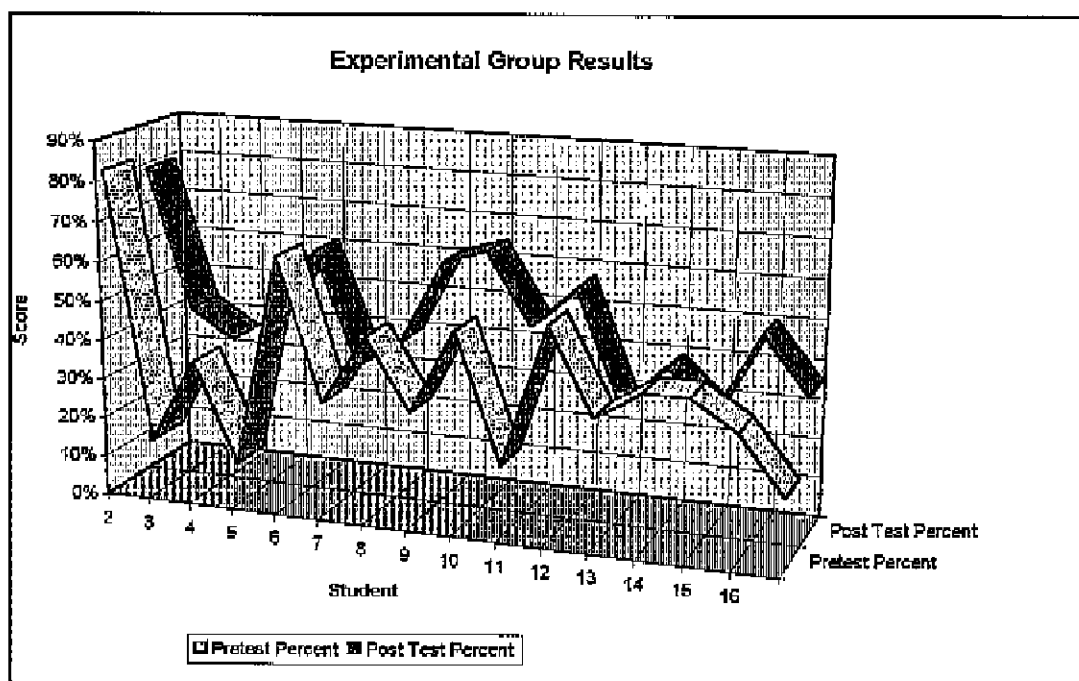


Figure 2

Figure 2 illustrates that 56% of the students in the Experimental group increased their scores, 31% decreased and 13% had no change. Two students in the ESL program demonstrated a 28% and 29% increase in their scores while one classified student demonstrated a 32% increase. Two other classified students increased their scores by 18% and one other increased by 3%. One classified student remained the same and one decreased in score by 10%. Three students demonstrated a 10%-20% increase, two were less than 10%, and two were unchanged. Of the five that decreased in their scores, three had less than a 5% decrease and one less than a 10% decrease.

Chapter V

Summary, Conclusions, and Recommendations

Summary

Recent evidence reveals that most American students leave school without mastering 8th-grade mathematics placing them at a greater risk, since they cannot adequately perform the vast majority of jobs, much less consider specialized careers in mathematics or science. These deficiencies in the general population are shocking, but the continuing failure of students with mild disabilities to master basic skills math is even more egregious. Furthermore, the lack of investigation and remediation of mathematics performance deficiencies among students with learning disabilities has not received the same level of attention as other areas, such as reading and language.

Special Education analysts have documented how the effective use of instructional time increases the achievement of students with mild educational disabilities. Further research has revealed that learning disabled students are inefficient learners. They have a unique way of processing information, exhibit inadequate and inflexible problem-solving strategies and their metacognitive processes operate differently. When these students who are participants in a regular educational mathematics setting involving more traditional methods of instruction, teaching fragmented and isolated skills and assessing only through quizzes and formal tests, are often times programmed for failure. A broad framework to

guide and reform school mathematics in terms of content priority and emphasis was published in 1989 by the National Council of Teachers of Mathematics. Stemming from this documentary new philosophies concerning strategies, techniques and assessment methods have surfaced. Various program models have been developed and implemented in regular education settings with success. Since these researched models have proven to be an effective means of developing critical thinking skills and meaningful mathematics in a regular educational mathematics setting, would a learning disabled student participating in this type of environment be programmed for failure?

Research Questions

The research questions were as follows:

1. Is it possible that students learning through a cognitive apprenticeship model might transfer and flexibly use advanced cognitive skills with greater proficiency in a formal assessment than other students?
2. Will students acquire and be able to integrate cognitive and metacognitive strategies in a cognitive apprenticeship model incorporating a task performance project?
3. If the methods of more traditional instruction which are more geared towards academic performance on standardized tests, are employed, how well could these students transfer and flexibly use advanced cognitive skills in an authentic situation?

Design of the Study

The sample consisted of 27 seventh-grade students attending the Arthur Rann Middle School in Galloway Township. Eleven of the students were assigned to Basic Skills Instruction in mathematics and 16 were assigned to a regular educational

mathematics class. Within the 16 students assigned to the regular educational class, 6 were eligible for special educational services, 2 were students in the English as a Second Language program and 8 had previously been eligible for Basic Skills Instruction.

A criterion-referenced assessment focusing on basic skills arithmetic and fractions was constructed and administered to all the students initially and at the end of the study. The design of the instrument was a hierarchical format requiring students to apply information about a given concept and make a multiple-choice response.

Over a four month period the control group continued to be taught through traditional teaching techniques while the experimental group worked on a task performance project, *Games-Recycled Math*, as described in Chapter 3. They further experienced researched teaching strategies and techniques. Both samples used the same room for their lessons.

Conclusions

Would differences in teaching styles have a definite influence on students' abilities to perform on criterion-referenced tests with multiple choice responses, or would they have little to no impact? An examination of data indicates the following results:

1. With respect to the primary question of the affects of teaching strategies on student's performance on a formal assessment tool requiring a multiple choice response, data revealed that there was no significant impact upon the groups.
2. When students were examined individually, ESL and students receiving special education services improved. The two students in the ESL program improved by 28% and 29% while one classified student demonstrated a 32% increase. Two other classified

students increased their scores by 18% and one other increased by 3%. One classified student remained the same, one decreased in score by 10%, and two were unchanged.

3. The third question could not be answered due to circumstances beyond the examiner's control.

Even though group data suggest there was no significant impact of teaching strategies and techniques on students' performance in a formal assessment, comparison of individual scores indicate that some students' scores were greatly improved.

The data should be interpreted cautiously, since the sample was small, and an authentic assessment could not be completed. The groups were nonequivalent as to the number of subjects, attitude assessment could only be collected in the experimental group, and educational levels in reading abilities varied as well as types of learning disabilities. Also, it is possible that a hidden variable, such as the assessment tool not having an impact on individual grades, could have confounded results. For instance, one student in the experimental group was upset about having to take the test because he would have rather worked on his project. Furthermore, the test was administered on different days of the week due to the examiner not being in charge of the Control Group. The Control Group took the post test on Monday whereas the Experimental Group took the post test on Friday.

Recommendations for Further Research

Anyone wishing to further investigate the impact of authentic problem-solving experiences in mathematics might get more conclusive results with the following adjustments to the present model.

1. Use a sample large enough to allow for subdivision of groups between reading levels and disabilities.
2. Use a task performance project that has already been developed and refined.
3. Ensure control over both groups so that an authentic assessment as well as a formal assessment can be made.
4. Research the language of math and its role in bridging the gap between authentic assessment and formal assessment.
5. Include an attitude assessment.

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APPENDIX A

Mathematics Game Design Project

By Nancy R. Peterson

Phase 1 - 11/14/94

I. Goal:

Plan, design, and construct a mathematical game.

II. Purpose:

- A. Explore the many problem-solving activities within a game.
- B. Thoughtfully evaluate and accurately analyze elements of diversity in games.
- C. Imaginatively and thoroughly establish principles of a game.
- D. Communicate the game idea and design in a written and oral format.

III. Criteria:

- A. Using a study guide focusing on mathematical concepts, explore the problem-solving possibilities involved in four games from a game packet and list at least three math concepts utilized for each of the four games. Then examine the diversity of the four games selected, differentiating between types of games, (i.e., skill, luck/chance), and the creation of the games, (i.e., mazes, cards, memory, puzzles, etc.).
- B. Using a study guide, review a packet containing rules for four different games. List five essential sections each of the set of rules includes, rate the readability on a 1-4 basis (4 being the highest), and define objective.
- C. Using a study guide, examine homemade games and create an objective and a name for each game.
- D. Using a study guide, select a homemade game and write a set of rules for it. Be sure to include the five parts of rules that were deemed essential from "C".
- E. Using a study guide, explain the design of the group's planned game. Determine the objective, the construction, type of game and the proposed materials needed.
- F. Using a study guide, prepare a written summary of the planned game and present it orally.

IV. Grading:

- A. Group grades will be determined from evaluation sheets.
- B. Individual grades will be determined in three ways:
 1. Utilization of an assessment tool that measures three levels of understanding the problem or situation: not understanding, developing, and understanding and applying.
 2. Criterion referenced assessment involving free response or multiple choice.
 3. Criterion referenced assessment following review and discussion of study guide.

Mathematics Game Design Project

By Nancy R. Peterson

Phase 2

I. Goal:

Plan, design, and construct a mathematical game.

II. Purpose:

A.. Generate a budget for materials necessary in the construction of the game and maintain accurate accounting of all monies.

B. Facilitate a process to calculate labor and credit card expenditures.

B. Develop and effectively implement an objective and a set of rules for a mathematical game focusing on concepts involving fractions.

C. Successfully create and construct a gameboard.

D.. Accurately self-assess and self-correct the objective and set of rules.

E.. Communicate in an appropriate variety of media the intent of their game.

III. Criteria:

A. Organize a method upon which accurate maintenance of debits and credits can be achieved.

1. Using a study guide and a materials' cost list, create an estimated budget for materials needed in the development of the group's game.

2. Use a ledger sheet to maintain accurate accounting of monies.

3. Use a time card to keep track of minutes worked.

4. Keep all copies of purchase orders and record expenditures on ledger cards immediately.

B. Construction of your game.

1. Using purchased materials, construct your game.

2. Demonstrate neatness, creativity, individual effort, effective use of time, and cooperation with other group members.

C. Self-assess and self-correct your game.

1. Use the computer to write the set of rules to your game.

2. As a group play your game. Make notes as you go along as to what changes might need to be made to the objective, the game board, or the rules.

3. Display your game for all the groups. Each group will play another group's game. Upon completion of the game, the group will develop a list of positive points of the game and suggest some ways the game might be improved.

4. Each group will review their games one last time. Then a final copy of the rules will be submitted.

D. Marketing your game.

1. Make a poster of your game in the form of an advertisement.

2. Develop a commercial for television to sell your game.

3. Prepare a newspaper advertisement.

IV. Scoring: Same as Phase 1

APPENDIX B

GAMES
STUDY GUIDE 1A - ORANGE
Exploring Problem-Solving Activities Within Games

DIRECTIONS:

Select **four** (4) games from the handout. Read the summaries carefully and look closely at the games.

1. As you read the summaries and examine the pictures of the games, think about what problem-solving activities might be involved if you were playing the game.

2. If the summary does not give enough clues, try and guess what problem-solving might be involved from the pictures.

3. Use the outline below to gather your information.

Game 1: Title _____

A. _____

B. _____

C. _____

Game 2: Title _____

A. _____

B. _____

C. _____

Game 3: Title _____

A. _____

B. _____

C. _____

Game 4: Title _____

A. _____

B. _____

C. _____

Answer the following questions:

1. If your group could buy any of the games on the paper, which one would you buy?

Give three reasons why.

A. _____

B. _____

C. _____

2. Look at each of the games you selected again. Tell whether the game was one of luck, chance or skill.

Game 1: _____

Game 2: _____
Game 3: _____
Game 4: _____

3. Looking at the construction of the game, try to describe the way it was designed (i.e., mazes, cards, board game, memory, puzzles)

Game 1: _____
Game 2: _____
Game 3: _____
Game 4: _____

4. You have now completed Assignment 1. Each individual in the group should now complete his/her index card explaining their contribution to today's assignment. The group should review each card and the leader of the group should initial all cards indicating they were reviewed and agreed upon.

Complete the card using the following format:

Name: _____ Date: _____
Period: _____ Group Name: _____

Contribution: _____

Evaluation of assignment:
Mathematical Concepts (5-8)
Curriculum and Evaluation Standards for School Mathematics
1989

Use the following to aid in brainstorming with students about a connection between mathematical concepts and games.

PROBLEM SOLVING

How to play
 How to win
 Possible strategies used within game.
 Objective

Logical Thinking-Reasoning

Similarities and differences
 Patterns
 Problem situations
 Skill or chance
 Idea behind game

Mathematical Connections

Game relationship between art,
 music, cultures, etc.
 Connections with various mathematical
 concepts

Numbers and Number Relationships

Whole numbers, fractions, decimals,
 percents
 Equivalent forms of numbers -
 dots on dice to numbers

**Number Systems and
 Number Theory**

Design of covering on game boards -
 number of spaces developing equations
 for board design, counting

Measurement

Understand the use of measurement
 Understanding the process of measurement
 Selection of appropriate tools to measure

Computation and Estimation

Four operations
 Estimation for moving players
 Simple calculations

Patterns and Functions

Describe, extend, analyze and
 create variety of patterns used
 Use of patterns to solve
 objective

Probability

Spinners, dice
 Winning

Geometry

Identify, describe compare
 geometric figures on games
 and game boards
 Explore transformations of
 geometric figures
 Developing an appreciation of
 geometry
 Apply geometric properties
 and relationships

GAMES
STUDY GUIDE 1B - YELLOW

Reviewing Rules of Games

I. Review the handout of rules for games.

- A. The rules for **SHUT THE BOX** has how many sections? ____
- B. The **MEMORY** rules have how many sections? ____
- C. How many sections are in the **CAREERS** rules? ____
- D. How many sections are in the rules for 24? ____

II. Compare all the game rules.

A. Do any of the game rules have the same titles (although not the exact wording) for sections explaining some part of the game? ____

B. What are those sections that appear to have the same titles?

C. Place a number in front of the game indicating how hard the rules are to read (Can you understand all the vocabulary?)

4 = real easy to understand; 3 = easy to understand;

2 = difficult to understand; 1 = hard to understand

____ **SHUT THE BOX**

____ **MEMORY**

____ **CAREERS**

____ **24**

D. The ones you marked with a 4 or a 3: Why do you think they were easy to read and understand? _____

E. Why were the games you marked with a 2 or a 1 hard to understand?

F. What is an objective? _____

G. Was it easy to find and understand the objective of all the games you reviewed?

GAMES
STUDY GUIDE 1C - LIGHT BLUE
Writing Objectives

I. Examine the homemade games around the room.

A. Make up a name for each game and list it below.

- A. _____
 B. _____
 C. _____
 D. _____
 E. _____

II. Now write what you think the objective might be for each game.

A. Game 1: _____

B. Game 2: _____

C. Game 3: _____

D. Game 4: _____

E. Game 5: _____

III. Be sure to fill your index card out. Use the following format in setting it up.

Name:

Date:

Period:

Group Name:

Your contribution (what exactly did you do to help your group fill out this sheet). Did you split the games among yourselves and then compile your information or did you do each game together? Do you think you did as much work as everyone else in your group?

Evaluation of assignment. What did you think about today's work?

GAMES
STUDY GUIDE 10- PURPLE
Writing Rules

I. List five important sections that should be included in rules.

A. _____

B. _____

C. _____

D. _____

E. _____

II. Review the games. Select one and write a set of rules using the five sections above as a guide for what information should be included within your rules for the game.

A. _____

B. _____

C. _____

D. _____

E. _____

GAMES
STUDY GUIDE 1E - PINK
Designing Your Game

I. As a group determine the objective of your game.

A. _____

B. Tell whether your game will be one of skill, luck/chance. _____

II. Keeping in mind that your group will be focusing on concepts involving fractions when designing your game, describe the proposed construction of your game. Tell whether it will be a board game, involve cards, be wooden, etc. What idea will you use - mazes, puzzles, paths, etc.?

A. Construction of game: _____

B. Idea of game - mazes, puzzles, paths: _____

III. What materials will be needed to construct your game? _____

V. Complete your index card being sure to include your contribution to the group and your evaluation of the activity. The leader must review and initial the cards.

Name:

Date:

Period:

Group Name:

Contribution:

Evaluation of today's activity:

APPENDIX C

Games-Recycled Math
Project Evaluation Sheet
Study Guides

Name _____

Grade _____

Exploring Rules

Study Guide 1A (15 points)..... _____

Study Guide 1B (10 points)..... _____

Study Guide 1C (10 points)..... _____

Study Guide 1D (10 points)..... _____

Designing Your Game

Study Guide 2E (5 points)..... _____

Study Guide 2A (15 points)..... _____

Budget

Study Guide 2B (5 points)..... _____

Rough Draft of Rules

Ages/Number of Players (5 points)..... _____

Equipment (5 points)..... _____

Objective (5 points)..... _____

How to Play (10 points)..... _____

How to Win (5 points)..... _____

Games Project Design Evaluation Sheet

Name: _____ Grade: _____

The Game

Creativity of Idea (10 points)....._____

Individual Effort (10 points)....._____

Neatness (10 points)....._____

Study Guide 20 Salary (10 points)....._____

Effective Use of Time (10 points)....._____

GAME CARDS (2 OF EACH TYPE) Study Guide 2D

Type I - Operations with Fractions & Decimals (10 points)....._____

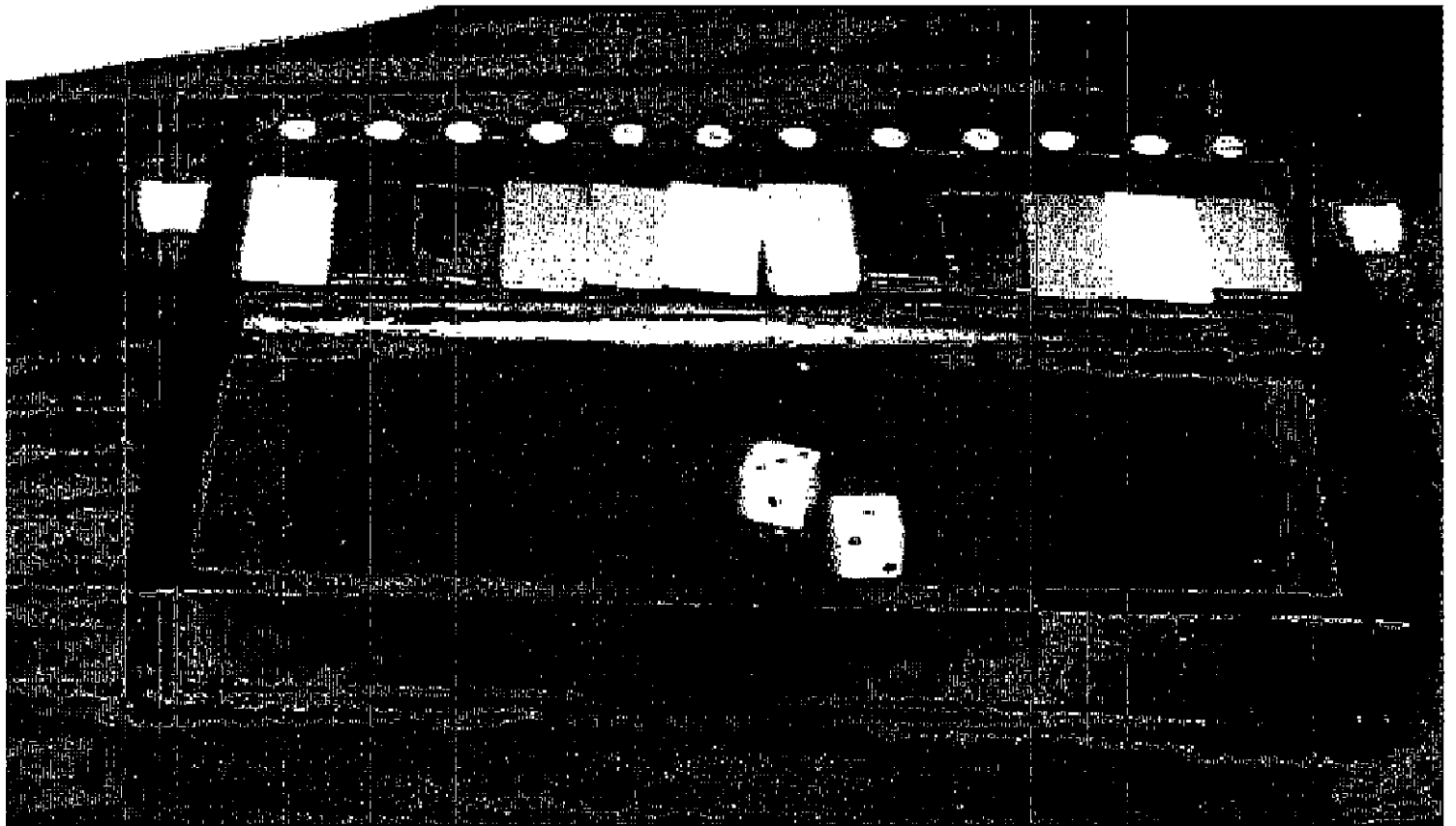
Type II - Ratio/Proportions/Percents (10 points)....._____

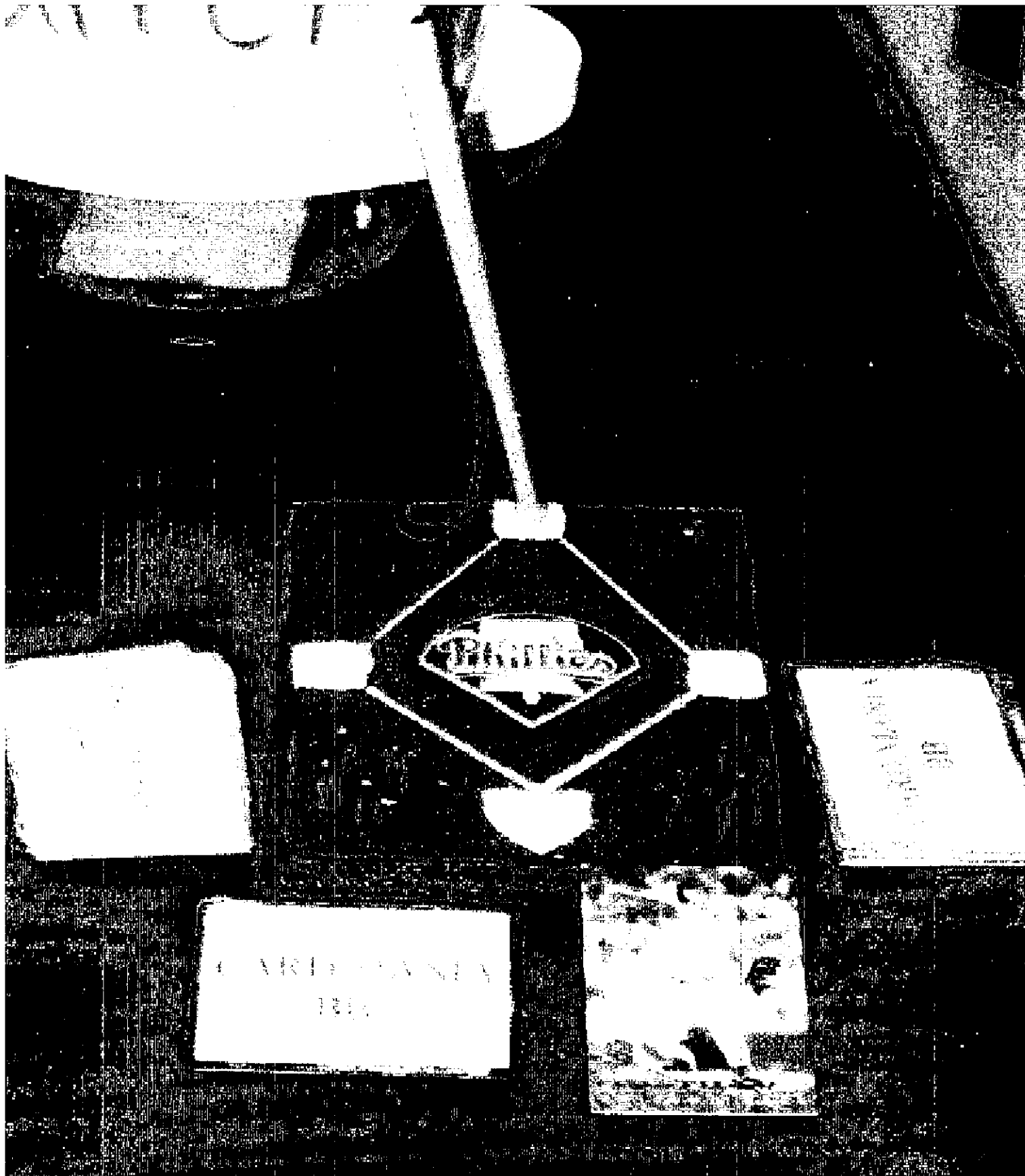
Type III - Probability (10 points)....._____

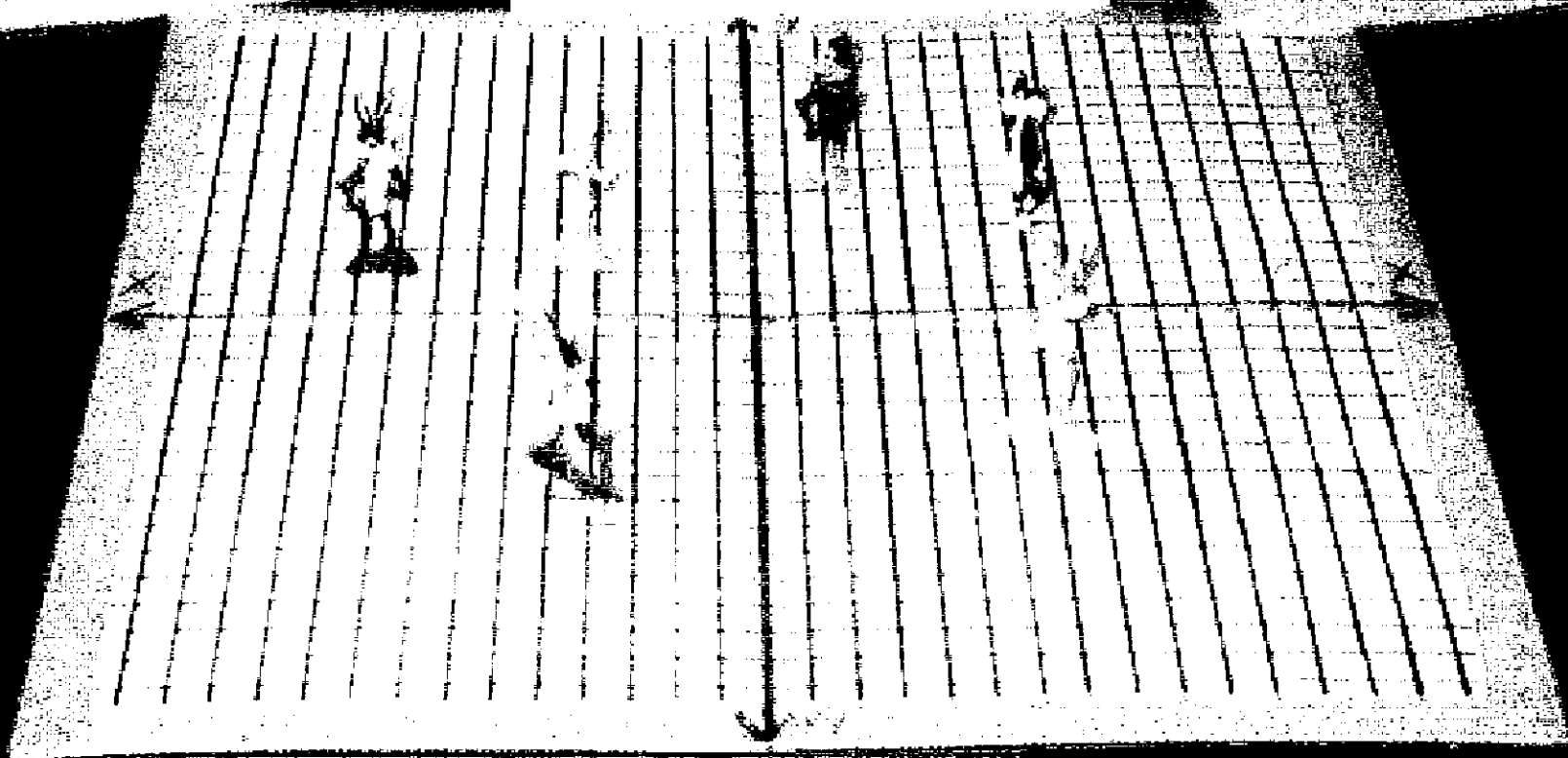
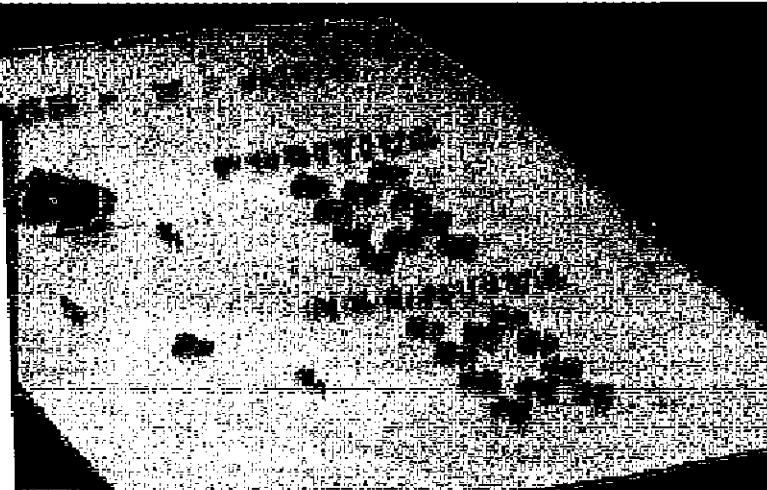
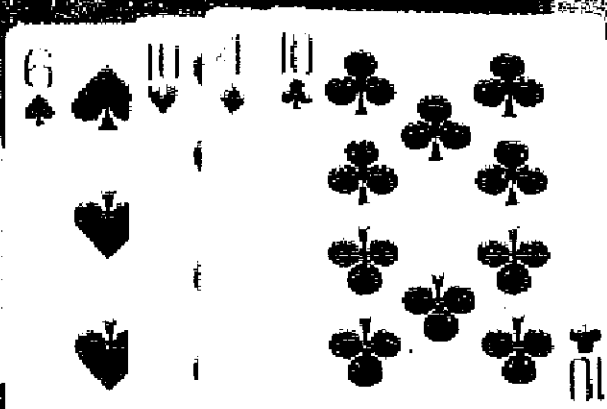
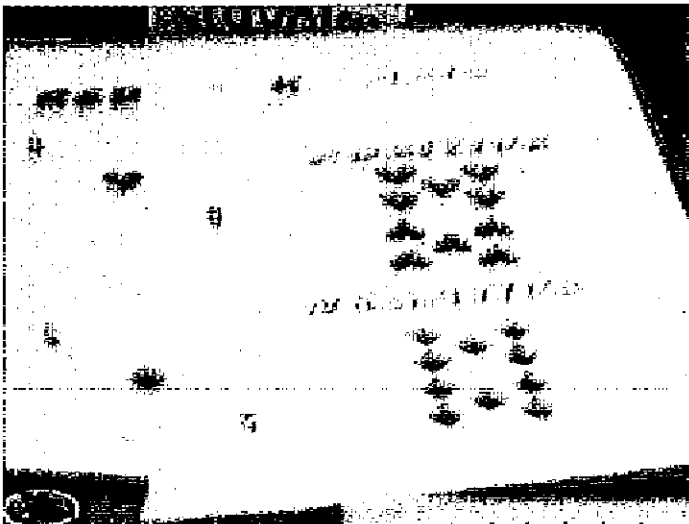
Type IV - Measurement (10 points)....._____

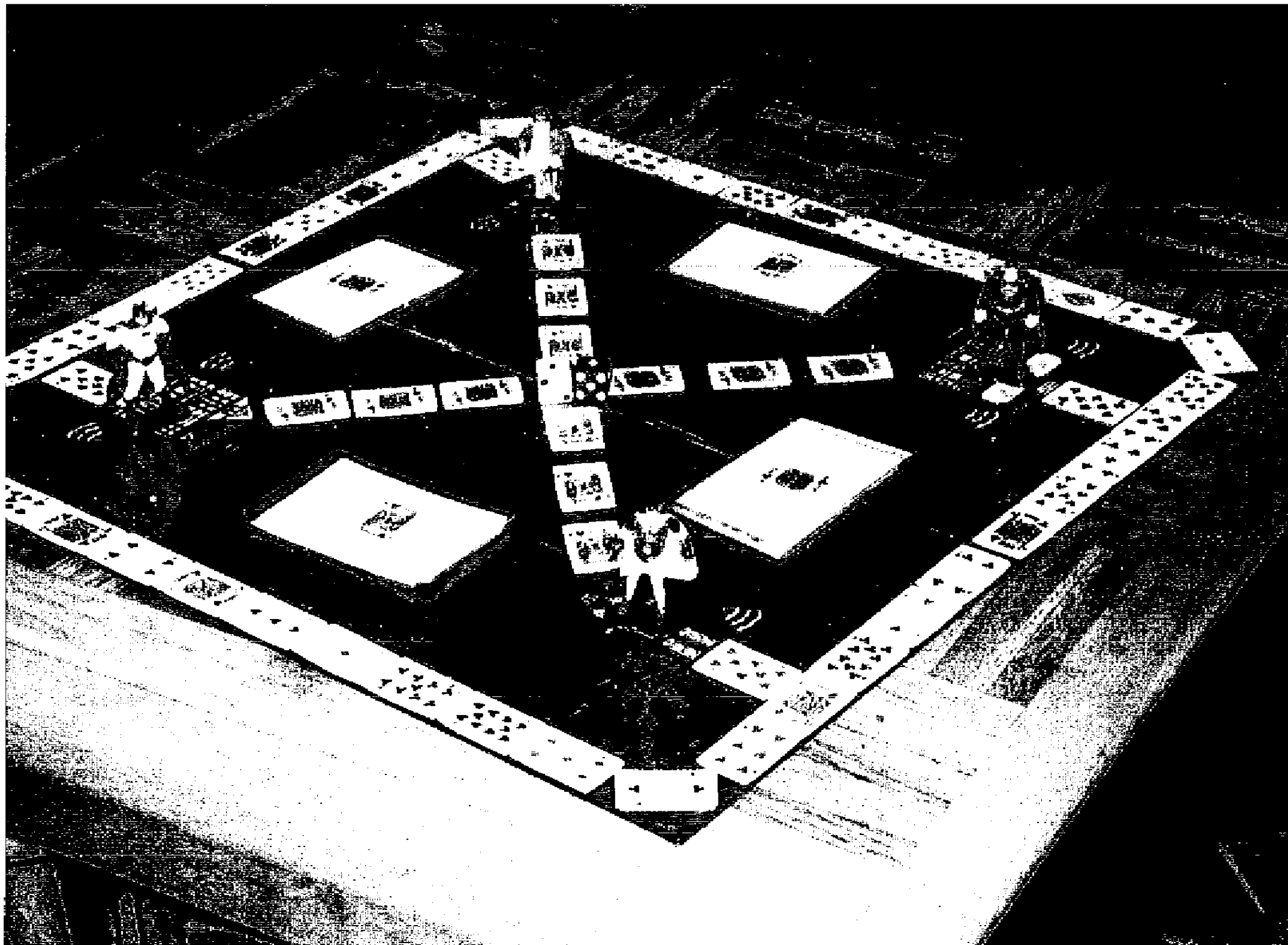
Type V - Patterns with Fractions (10 points)....._____

APPENDIX D







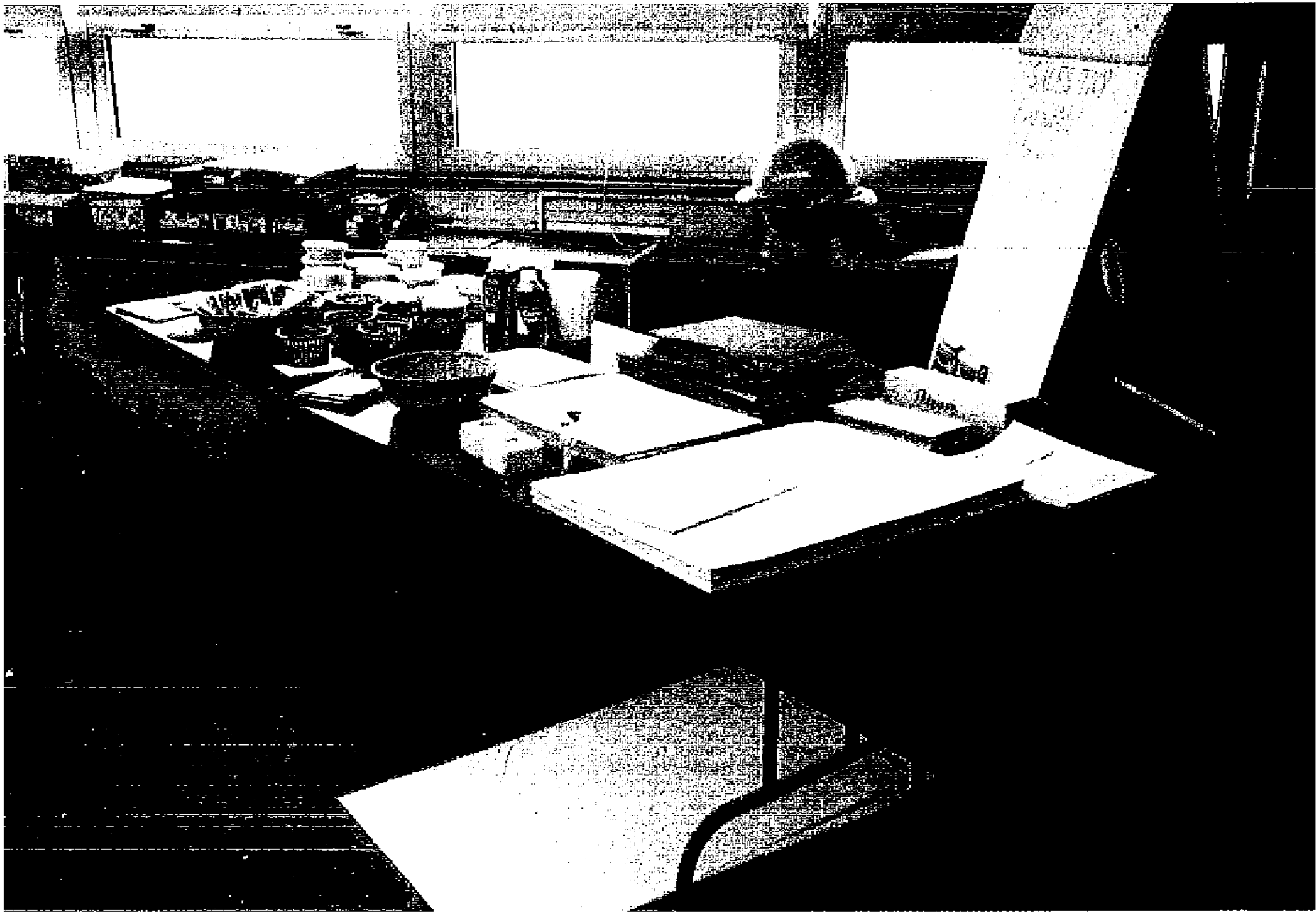


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APPENDIX E

MATH MASTER GOLD CARD

CONGRATULATIONS! Your company has been pre-approved to receive the MATH MASTER GOLD CARD with no annual fee. A **\$500 pre-approved** credit line has been extended to your company at a low **1.5%** monthly rate. To gain access to your pre-approved credit line just write a business letter to GAMES-RECYCLED MATH, Arthur Rann Middle School, Attn: N.R. Peterson, Room 7. Then simply use your card to purchase any materials necessary for *GAMES-RECYCLED MATH!*

EARN CREDIT towards paying your bill. If all members of your company receive a **92 or above** on a test, **5%** of your bill will be credited to your account! Or receive **1%** for each student (maximum of 3) in your company that receives a 92 or above on a test.

Receive **2%** of your bill as credit if all members of your company hand in their homework **every** week!

Can your company work together? If so you may be **eligible** to receive a **1%** of your bill as credit. Simply be sure to delegate assignments to every member of your company and fill your response cards out correctly!

Keeping track of your finances is always difficult. However, if your company can **maintain** a budget by correctly computing expenditures, credits and a correct balance, you **will receive 3%** of your bill as credit.

Terms and Agreements for MATH MASTER GOLD CARD:

1. Finance charges will be based on a 1.5% monthly rate. Bills will be presented on a weekly basis. payment due within 7 days upon receipt of bill.
2. If full payment is not received within 7 days, a finance charge will be applied to the balance. 15% of the balance will then be the minimum payment due.
3. Pre-approved customers can obtain cash advances at an additional .5% immediate charge. This additional charge will continue on a weekly basis until the cash advance is paid in full.

**GAMES
STUDY GUIDE 2-B
THRUQUOISE**

DEVELOPING A BUDGET

I. Estimating costs

A. With the understanding that each person in your group will be paid \$5.15 per hour, explain each of their responsibilities.

B. Using the price list, estimate the cost of the materials necessary for the construction your game.

D. Today is the only day that everyone will donate their time to the project. At this time everyone should assume their responsibility and begin work on your game.

II. Upon completion of the estimated list of materials, use the practice purchase order to prepare the actual request. Then use the real purchase orders in your folders to buy your materials. Be sure to fill it out properly! USE THE COMPLETED ONE IN THE FRONT OF THE ROOM AS AN EXAMPLE.

A. If using cash to pay for your purchase, simply use your group's name after TO.

B. If purchasing your materials by credit card, place your company's name after TO. Place your card number under address. Be sure to fill in the date.

C. Be sure to keep a copy for your records.

III. Salaries

A. Keep track of time worked by filling out the time card.

B. Skip days that you are absent.

C. Calculate salaries on Study Guide 2B.

PRICE LIST FOR MATERIALS

GAME BOARDS ***\$.05/IN.**

MEASURE THE PERIMETER OF THE BOARD TO GET TOTAL INCHES.

COVERING FOR BOARDS

\$.02/SQ. IN.

MEASURE THE AREA OF THE BOARD TO GET SQUARE INCHES.

LAMINATING ***\$.04/SQ. IN.**

DICE

FRACTION DICE *SET OF 3 ***\$3.95**

BLANK DICE **12 DICE****\$3.95**

REGULAR DICE ** 5 SETS (6 DICE EACH) \$18.50

OPERATION DICE ** SET OF 6 *\$5.95**

SPINNERS

BLANK SPINNERS - SET OF 5 - \$4.00

SPINNER HARDWARE - SET OF 8 - \$3.95

CARDS

REGULAR DECK *\$1.99/DECK**

BLANK CARDS *5.99/DECK**

FRACTION CARDS *\$3.99/DECK**

**GAME PIECES-PRICE AS MARKED
WOOD BASES ****\$.75/IN.**

MEASURE THE PERIMETER OF THE WOOD FOR TOTAL INCHES.

FELT *** \$3.99/SQ. IN.**

TIMERS - RENTAL - \$3.50/HR.

**PAINT, MARKERS, CRAYONS
FLAT FEE OF \$10.50**

POSTER PAPER - \$2.99

VIDEO COMMERICAL-\$150.00/MIN.

NEWSPAPER AD

1/4 PAGE AD *\$25.00**

1/2 PAGE AD *\$50.00**

3/4 PAGE AD *\$75.00**

FULL PAGE AD *\$100.00**

WAGES ***\$5.15/HR.**

**6% STATE SALES TAX WILL BE
APPLIED TO ALL PURCHASES.**

GAMES
STUDY GUIDE 2B
Planning the Game

Ann, Mary, Tom and Mike had completed their plans for their math game. Their money had been gathered, summaries of their games had been written and approved and it was now time to just put the game together.

The group knew that they had to purchase their materials from a price list. Additionally, they all knew that each member was to receive a salary, and that they would have to market their game. The one thing they weren't ready for was trying to develop a budget based on the amount of money they had available. When they received this information, the group quickly appointed Ann as their business manager because she was good in math.

Ann accepted the challenge and like all good managers, she delegated jobs to each of her partners. Tom was given the job of writing the rules. He was great in communication arts and had a talent for creating stories that everyone enjoyed. Ann asked Tom to estimate how long it would take him to write a rough draft for the group to review and a final draft to present with the game.

Mary and Mike volunteered to prepare a purchase order for the materials. Since they were artistic and creative, they could make decisions on what materials would be best. They also decided to make a rough copy and present it to the group for approval before actually making the purchases.

Everyone completed their jobs and met as a group to discuss their proposed budget. Ann had divided her budget into three major areas: Materials, Marketing, and Salaries. She then listed the cost of various items under each heading and found a subtotal. The one area that presented a problem was the salaries. No one seemed to be able to estimate how long it would take them to do their work. They did know that their actual expenses at this point were approximately \$313.19.

The group was aware that they had \$230.00 in cash and if they wrote a business letter to Mrs. Peterson informing her who was authorized to sign for credit, they would have an additional \$500.00 credit line through the GOLD CARD. They had also read the small print regarding the terms and agreements which meant that they would have to acquire credit through some manner as described in the introductory offer. Ann definitely had her work cut out for her in keeping track of her finances. She also needed the help of the entire group to earn credit for any monies they might borrow.

The big question became: Can they develop their game and survive bankruptcy? Ann decided to approach this problem one step at a time. Because they definitely had to purchase their materials, that was where they started.

After Mike and Mary presented their rough copy, the group agreed on the materials needed and set up a budget sheet to show exactly what was bought and the price for each item. They all decided to use their credit card and were committed to working together to earn credit in paying it off. Another thing everyone agreed on was to hold off on actually investing in their marketing plans. It was obvious that this was not absolutely necessary at this time and due to the their financial status, the marketing plan might change.

Ann suggested that they use their cash to pay the salaries. Each member submitted a time sheet which recorded their hours worked. Ann paid each member who filled out a receipt and recorded it on her ledger sheet.

So far The Group had survived Day 1 of *GAMES*, but could they win? Stay tuned for the next exciting chapter when The Group makes their game! Will they be able to work together to achieve their goal? Will they be able to earn credit towards their GOLD CARD expenses? What will Ann's next course of action be towards record keeping? Did Mary and Mike buy the right materials?

Now its your turn. Use the Bright Pink sheet in your packets as your guide for today's work. Use the white sheets to brain storm. **Good Luck!!**

GAMES
STUDY GUIDE 2C
PAYMENT # 1
Hourly Pay Guide

In the spaces below calculate the hourly pay for each member in your group.

1. First find the total minutes worked for each member. Then convert the minutes to hours. Hours are to be represented as decimals then as a fraction.

	<u>Name</u>	<u>Minutes</u>	<u>Hours</u>	<u>Hours</u>
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____
4.	_____	_____	_____	_____
5.	_____	_____	_____	_____
6.	_____	_____	_____	_____

2. Now multiply the hours by the hourly rate of \$5.15 and enter the total.

	<u>Name</u>	<u>Hours x \$5.15</u>	<u>Total</u>
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____
6.	_____	_____	_____

3. Now fill out a receipt for each person in your group for the amount you are paying them. Then have each person sign the receipt after receiving their money. Hand the original receipt and time card in to me and keep the copy for your records.

4. Each person in the group should update their ledger at this point. Be sure to check whether more purchase orders have been submitted and deduct those sums as well.
5. Each person is responsible for his/her money. Don't loose it between today and tomorrow. You are going to deposit it in the bank and I'll know how much each person should have.

HAVE FUN !!!

GAMES
STUDY GUIDE 2D

DEVELOPING PROBLEM-SOLVING CARDS

I. Each game has been designed to encourage the participants to learn about fractions. Since there are so many concepts involved with fractions, the following criteria has been developed to aid in construction of your game.

- A. Your problems should be designed to include:
1. Illustrations or operations (+, -, x, --) of fractions and decimals.
 2. Use of ratio, proportion, and percent.
 3. Use of probability for developing or applying ratios, fractions, percents, and decimals.
 4. Estimating and using measurement.
 5. Use of patterns in understanding fractions. Ex: equivalent fractions.

II. Suggestions for collecting types of problems described above include:

- A. Use of your notebook for examples and information that will be given in class.
1. Each concept mentioned above will be taught in class. Emphasis will be placed on the number representing the concept above so that you can easily match the type of problem to the concept mentioned.
 2. After each class, write your homework assignment not only in your agenda book, but at the end of your notes. Then you could use some of the homework problems for your games. (You cannot copy them, but you can make up your own that are similar to the type of problem given.)
- B. You may use a variety of sources to help you create problems.
1. Textbook-use Table of Contents or Index.
 2. Worksheets given as homework or additional credit.
 3. Math textbooks from other grade levels.
 4. Teachers
 5. Friends (As long as they have a complete understanding of the concept.)

III. Each student in your group is responsible for creating problems used in your games. The following conditions must be observed to receive full credit on your projects.

- A. Each student is to create at least two (2) problems from each category listed in Part I, Section A. That is a total of ten (10) problems each.
1. The problem must be on an index card.
 2. The problem must be clearly labeled as to which category it goes with in Part I, Section A

3. The problem must be original in nature. You may use the idea presented but not the exact words.
4. The problem must be written clearly so there is no doubt as to what numbers or words are being used.
5. On the back of the index card, the problem must be solved correctly. All work must be shown as to how the problem was solved. All work must be in the student's handwriting. *Remember this exercise is designed for you to learn. Your grade will be based more on your effort, understanding in matching types of problems, and for knowing and doing the proper computation.*
6. When each student has completed two (2) of each type of problem mentioned above, he/she must hand all the cards in for a grade BEFORE using them in the game.

APPENDIX F

SAMPLE OF ONE STUDY GUIDE ASSESSMENT

*MATH ASSESSMENT**PART 1*

I. Examine the game on this page. List three math concepts that might be involved in this game.

A. _____

B. _____

C. _____

II. Tell whether you think the game is one of luck, chance, or skill. Explain your answer.

III. Describe the construction of the game. A) What is the perimeter and B) what is area of the board? C) How much would it cost to buy the board? D) If you had \$1,000 could you cover the board with felt? If you received change, how much would you get back?

A. _____ B. _____

C. _____ D. _____

IV. Upon review of the rules to four games, you found at least five common sections in all the sets of rules. List them.

A. _____ B. _____

C. _____ D. _____

E. _____

V. What do you think the objective of this game might be? If you were to name this game, what would you call it?

A. _____ B. _____