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THE EFFECT OF TIME ON COMPUTER-ASSISTED
INSTRUCTION FOR AT-RISK STUDENTS

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

Doctor of Education

By

Christopher A. Salerno, B.A., M.S.

Denton, Texas

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The problem of this study was to determine if the mathematics achievement of at-risk students using computer-assisted instruction (CAI) differed significantly from other groups of students.

One hundred nineteen at-risk fifth graders were selected at random from across a suburban school district and assigned randomly to one of three groups: extended computer time (T1), extended time-on-task (T2), and a control group (C). All fifth graders used classroom computers; the T1 group spent an extra 60 minutes per week engaged in CAI. The T2 group had special workbooks and worked for an equal amount of non-instructional time independently. Students took a pre-test in December and a post-test in May using alternate forms of a criterion-referenced mathematics test developed in the district. Software that was correlated to the text, to the state essential elements, to the workbook, and to the instruments, was available in the classroom to all students in the district.

Mean gain scores were computed for each group and were examined using analysis of variance tests and Scheffé tests

of multiple comparisons. A one factor ANOVA was conducted on treatments and a two factor ANOVA was conducted on treatment by gender.

Analyses indicated that there was a significant difference in achievement between boys having extended CAI time and boys engaged in extra workbook time. Girls having extended computer time achieved greater gains than girls in the workbook group, but not at a statistically significant level.

Recommendations for future research included: 1) replication of the study with students in other grades; 2) use of the study as a model for a year-long or longitudinal investigation; 3) using the study as a model to test differences in other academic areas (composition, reading, science, history) or using other forms of CAI; 4) replication of this study with the addition of a test of correlation between post-test scores and mathematics class scores; 5) replication of this study with other amounts of time allotted to CAI.

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I. INTRODUCTION

A. Background

In the early 1960's, when the computer was first introduced into schools, it generated a considerable degree of excitement among educators, educational psychologists, and the American public. It was envisioned that every student would have a computer at his disposal, a non-judgmental, patient, adapted, personalized, and reinforcing tutor. The potential for students of all ages and ability levels seemed limitless with this kind of resource available.

The term "microcomputer revolution" is used to describe the widespread use of microcomputers in schools since 1980. It implies that recent computer use has dramatically improved classroom methods and instructional effectiveness. Society has very special measures for the effectiveness of the educational system: student achievement, attitudes, dropout rate, learning time. After twenty-five years of computer use in education, including a decade with microcomputers, the impact of computer technology on these measures remains largely unknown (Roblyer, 1985). Evidence suggests that the microcomputer boom is all around us, but whether this technological revolution translates into an

educational revolution is still a question. Is the computer being used as an updated version of the programmed learning machine developed by B. F. Skinner thirty years ago? Is a computer just another electronic teaching machine in the classroom or is it the focus of significant change? Just "adding" computers to a class setting is neither an adequate nor an appropriate strategy (Kemppainen, 1984). Lepper (1989) directly accuses the American education system of an inadequate and improper use of current computer technology.

Despite flurries of interest in new instructional technologies, such as educational television, language labs, and programmed learning, life in the classroom has remained largely unchanged . . . the last "technology" to have had a major impact on the way schools are run is the blackboard. Strong conservative forces and powerful constraints have traditionally made innovation in schools a slow and fitful process (p. 174).

Our school-age population is experiencing turmoil exhibited by elevated levels of economic hardship, teen pregnancy, substance abuse, gang activity, and dropping out. This turmoil and syndrome of failure existing during a technological revolution are cause for profound concern and are seen as true crisis in our society (Carnegie Council on Adolescent Development, 1989; Caught in the middle: Education reform for young adolescents in California Public Schools, 1987).

The term "at-risk" first appeared in education literature following the publication of the federal report, A nation at

risk (National Commission on Excellence in Education, 1983). In this report "risk" was defined as a rising level of mediocrity and failure threatening the future of American society. Since then, connotations have expanded and refer to any student at-risk of dropping out of the educational system due to academic failures, gang involvement, substance abuse, limited English proficiency, and low academic ability.

Each year new dropouts cost the nation \$260 billion in lost taxes and earnings. In 1986 the Bureau of Census put dropout estimates at 44% of Hispanic students, 36.5% of African-American students, and 26% of Anglo students, all of them functioning below grade level. These figures relate only to those leaving elementary school; percentages are almost twice as large for secondary students (Carnegie Council, 1989). Based on the most recent statistics from the Texas Education Agency, 25% of Texas students drop out, most with minimal or inadequate skills (Dallas Morning News, June 30, 1990).

The Coleman report (1966) focused on the relationship between academic achievement and socioeconomic background (SES). It demonstrated a close relationship between economic background and mathematics achievement, with SES explaining a great deal of the variance in mathematics achievement. Students from high SES families tended to achieve better than those from low SES families; students from urban areas tended to achieve slightly better than

those from rural areas.

Gibb (1982) updated the Coleman report and showed that children's attitudes appeared to become increasingly less positive as they progressed through school. Having students use CAI in order to make up for skills missed during absence from school fostered a positive attitude toward school and the academic subject and fostered positive self-esteem (Tanner, 1987). Kloosterman (1990) demonstrated a correlation between student attitude toward mathematics and achievement. He isolated five reasons for low achievement:

1. belief that the student cannot do mathematics;
2. reinforcement of mediocre work by poorly motivating teachers;
3. self-comparison to a norm rather than to personal achievement;
4. non-relevance of mathematics to their lives;
5. isolation in the traditional classroom.

In 1985 Henry Becker, a major researcher on the uses of educational computer technology, conducted the first national survey on the uses of computers in American public schools. Teachers and principals responded with an unfocused "need" for computers in schools rather than with strategic plans of acquisition and implementation based on educational goals and objectives.

The intuitive appeal of this concept is not accompanied by any strong research support...decisions with important policy implications are being made on the basis of truly minimal research evidence. (p. 28)

McCorduck (1986) indicated that parents, not teachers or administrators, were the driving force for getting computers in schools in the 80's. As late as 1987, Becker and Sterling were still warning that concrete evidence about the long-term impact of CAI was lacking.

The case for broadening the access to school computers--more computers and much more money--now rests on untested assumptions". Most responses to, "What works?" are based on personal experiences and little more than anecdotal reports, filled with threats to internal and external validity. (Becker, 1987a)

The picture that emerged of acquisition and implementation of computer technology in the classroom was one of educational cycles, "bandwagons", "the right thing to do".

Collis (1988) asked the pragmatic questions:

Where are we now? What do we know about computers and computer-related technology in the school setting? What works? Both those who fund us and the constituencies whom we serve are warranted in asking us these questions, especially since work in this area has been going on for a considerable length of time--at least since the 60's. (p. 8)

Between the years 1982-1985, the number of computers in schools went from 250,000 to well over 1 million; 75% of the schools that did not have computers, acquired them and started to use them. By 1986, 85% of K-6 schools in this nation had computers (with a student/computer ratio of 60:1). Twelve percent of American K-6 schools had more than 15 computers in their buildings; 51% had at least five. A

continuing trend was for schools that had more computers to use them more (Becker, 1987b).

Despite an increase in the numbers of computers available, students do not get to the computers. A 60:1 or 40:1 student-to-computer ratio cannot provide a student with a substantial amount of computer time. To provide 30 minutes of computer time for each student every day, a school would have to have one computer for every fourteen students, assuming no down-time at all during the day. As part of the educational reform movement of the 80's, some states mandated the number of minutes to be spent daily on each subject, eliminating any large blocks of time available for CAI or any other special activity during the normal five- or six-hour school day. By 1985, the typical elementary school had 35 minutes of computer time each week.

As cited in the opening paragraph, the future ideal was thought to be a one-to-one correspondence between students and computers. Baron (1986) stated that there would not be such a ratio of students to computers for years, if ever. Consequently, computers will continue to be a relatively scarce resource in schools, and time available to use them will continue to be limited. District and building administrators, as educational leaders, users of research, and managers of assets, will be challenged to provide optimum allocation of resources and to give priority access to those most in need of this strategy and who respond best to CAI.

B. Problem statement

The problem of this study is to determine the impact on mathematics achievement of time spent engaged in computer-assisted instruction (CAI) compared to other time-on-task in the regular classroom by elementary students who have been designated at-risk of failure. This study will address the question posed by Becker (1987): are the right students, those not succeeding through traditional instruction, getting enough time on the computer to make a significant difference in their mathematics achievement?

C. Significance of the Study

Collis (1988) quoted an editorial in Phi Delta Kappan which stated, "It is time to stop asking whether computer-assisted instruction works; we would do better to ask 'under what conditions should we expect transfer of skills?' " (p. 13). As discussed more thoroughly in Chapter II, the bulk of CAI effectiveness research has been conducted on mainframe or minicomputers, in samples of convenience, and for short durations (4 weeks or less).

We err in asking whether the computer is better than something else, but rather what aspect of computer learning is better than some other aspect of traditional lecture. It would be of interest to

see ...who is affected more in one domain and who in another. Computers do not really affect learners in any direct way; it is the way they are used that is crucial. (Salomon & Gardner, 1986, p.14)

This study looks at computer use in the classroom for a full semester under normal conditions rather than in a separate computer lab. The subjects of this study are a new category of students: those identified at an early age as being at-risk of not completing their education because of previous failure, low socio-economic status, gang involvement, abuse, or poor English proficiency. Individual performance is compared to state and district criteria rather than to national norms. The design is an experimental model, using random selection across a district and random assignment to treatment groups. The instruments used to measure achievement gain are correlated to state essential elements, district curriculum, state-adopted textbooks, and classroom software.

This study is not a defense of classroom computer-assisted instruction; that issue is a function of instructional leadership in a building. This study addresses other questions: are there grounds to target part of the elementary population for intensive use of CAI and to dedicate the scarce resources that computers represent to part of the student body, and does such an allocation makes a significant impact on academic achievement?

D. Limitations

Findings will be limited to 5th grade at-risk students who fall within an I.Q. range of 70-132, which excludes severely learning disabled and highly gifted students.

E. Assumptions

1. Based on the in-service (see Appendix B) and follow-up site visits, teachers will supervise treatments in a comparable manner.
2. Experimental groups will adhere to schedules for mathematics CAI and extended time-on-task.
3. All students will receive direct instruction and computer-assisted instruction during the course of this study; all students use computers in Texas schools as per Texas Education Agency directive.
4. Students will be able to transfer skills acquired in CAI and extended time-on-task to mathematics achievement measured on the pre-test and post-test.

F. Definitions of Operational Terms

Achievement was defined as student performance on the criterion-referenced pre-test and post-test developed by the

district. Content validity was established by a district committee of mathematics subject specialists and reliability was estimated through field testing at $r_e = .9$.

At-risk students were defined as those formally identified as in danger of dropping-out due to: achieving below the 40th percentile on standardized tests; having received failing grades on more than one academic course in the past school year; eligibility for free/reduced lunch (low socioeconomic status); limited English proficiency. All students in the district had been routinely evaluated to determine qualification for at-risk intervention; limited English proficiency was determined by use of the "IDEA" test or by a combination of methods (the district's Home Language Survey and performance on the "Stanford Achievement Test" below the 35 percentile in reading and writing).

Computer-assisted instruction was defined as drill and practice exercises that students could pursue independently.

Direct instruction was the time that a teacher spent in the direct-teach mode of the Hunter teaching model, i.e., explaining or demonstrating a skill. All students received one hour of direct mathematics instruction daily per district guideline.

Extended time on computer-assisted instruction (T1), for the purposes of this study, was sixty minutes each week.

Extended time-on-task (T2), for the purposes of this study, was sixty minutes per week beyond normal mathematics instruction devoted to mathematics paper and pencil activities (see also Appendix G).

Microcomputers used in this study were Apple IIe "stand-alone's" with 128 RAM and a disk drive.

Mathematics extended time-on-task, for the purpose of this study, was sixty minutes per week beyond regular mathematics instruction using the Electric Math workbook.

Mastery learning was defined as a method involving the teaching of ordered skills through a systematic cycle of teaching, testing and remediating to criterion performance levels.

Performance for the purpose of this study was defined as achievement measured by the district criterion-referenced mathematics tests used in this study (Appendices D and F).

The regular classroom was the conventional classroom where most direct instruction occurred and where the computer and

other centers were located; activities such as large and small group instruction and independent practice in mathematics and other subjects with all students took place routinely.

Standard time in computer-assisted instruction, for the purposes of this study, was thirty minutes per week for all students, including the control group.

Teacher In-service was a 30-minute presentation for teachers on procedures to follow with experimental groups in their classes (see Appendix B).

G. Hypotheses

- a. There will be no significant difference between the achievement gain scores of at-risk students who engage in the standard CAI time, who engage in "extended time" at CAI, or who engage in extended mathematics time-on-task (H_1).
- b. There will be no significant difference in the achievement of students of either gender in experimental groups (H_2).

II. REVIEW OF THE LITERATURE

Early studies of computers used in education dealt only with mainframe computers, which could handle a limited number of stations; the IBM 1500 could time-share 12 terminals at one time. Computers were freed from these short "leashes" to the mainframe when technology permitted operation over phone lines. In 1977 introduction of the microcomputer customized computing, making each unit independent, mobile, and capable of running different programs at the same time.

By 1972, enough studies had been conducted on the effects of computer-assisted instruction (CAI) in education to provide Vinsonhaler and Bass the data for the "grand-daddy" of computer-effectiveness reports; this collection of studies was an early attempt at meta-analysis, a technique later refined by Glass and discussed below. These studies involved elementary students using CAI from 5-15 minutes per day for mathematics and language arts drill and practice; all studies employed the Metropolitan Achievement Test and the Stanford Achievement Test for mathematics and language arts to measure student achievement.

While five of the sites showed no gain or negative results, twenty-nine sites reported significant gains. A major weakness in the studies was that no control groups

were used and time for CAI varied from site to site; nevertheless the authors did conclude that:

- 1) students using CAI for drill and practice learned more than students who experienced only conventional classroom instruction; and
- 2) CAI was more effective than classroom instruction alone.

The authors proposed that the sources or reasons for the advantage of CAI over traditional instruction might be due to one or all of the following: the direct effect of the computer drill, the novelty of the new medium, a change in student attitude because of the medium. From this time on, many studies have used "attitude" as a covariate when investigating effectiveness.

Jamison, Suppes, and Wells (1974) also looked at the impact of educational computing on achievement and reported that findings of no significant difference dominated the research literature. When small amounts (as little as 5 to 10 minutes per day) of CAI were used to supplement regular classroom instruction--as with elementary school drill and practice--substantial achievement gains resulted, particularly for slow learners.

Edwards, Norton, Taylor, Dusseldorp & Weiss (1974) conducted another early effectiveness survey over 33 studies covering a cross-section of grade levels and academic subjects. Concurring with the findings of Vinsonhaler and Bass; they also concluded:

- 1) that substituting CAI for traditional instruction was not effective; and
- 2) that drill and practice was the most successful and effective mode of computer-assisted instruction.

Studies compared CAI to other supplemental methods (language labs and programmed learning machines), but results were not significant. Although students took less time to learn some concepts using CAI than they did by direct instruction, retention was not as great. It was found that gains were greater for low ability students than for those with average or above-average skills, although results were not at a significant level. Gains for boys were greater than gains for girls; boys, girls, and their teachers developed positive attitudes toward CAI.

Lysiak (1976), one of the few researchers to use experimental design, investigated the effectiveness of CAI on Title I students in grades 1-6; significant effects were found in grades 3 and 4 only. This study differed from others in using the Iowa Test of Basic Skills in the spring as a pre-test and the same standardized test in the fall as a post-test.

In an address to the American Educational Research Association in 1976, Glass introduced a new technique for assessing research, an analysis of analyses or, as he dubbed it, meta-analysis. Meta-analysis is the application of multivariate analysis to the results of a collection of

individual studies in order to reduce the findings to commonalities and logical conclusions.

The process, which allows comparison of studies that do not always appear similar, begins with reducing measures of each study to a common scale, called the effect size. This is the difference between the mean scores of two groups (experimental and control) divided by the standard deviation of the control group. When reviewing a large cross-section of studies, quality of study and of reporting may vary, omitting some or all of this information; in that case, effect size can be calculated from t- and F-tests.

Critics of meta-analysis (McDermott, 1985; Clark & Stuart, 1985) have cited weakness in this techniques because it calls for the inclusion of all types of research, both strong and weak. They contend that the lack of a quality criterion would tend to distort the research, since designs which are the least robust would be biased in the direction of the treatment. Glass, McGaw & Smith (1981) defend this span of quality as a representation of the variation on which statistical analysis itself is based. Uncritically including all studies removes one kind of bias that is common in traditional reviews, the selection of students or studies that meet one's own bias.

Burns & Bozeman (1981) reviewed 40 studies covering all grades of the public school system. Their study looked at

the merits of drill and practice over tutorial as an effective use of CAI. They reported large effect sizes for drill (.34) and for tutorial (.44) over the span of grades K-12.

The study concluded that:

1. mathematics programs supplemented by CAI was more effective in fostering achievement than a program using only traditional instruction;
2. CAI was significantly more effective in promoting increased achievement for elementary students among high achievers and disadvantaged;
3. there was no evidence to suggest a relationship between design features and study outcomes;
4. the analysis and synthesis of many studies show a statistically significant enhancement of learning in instructional environments supplemented by CAI, at least in mathematics (p. 37).

This report, along with the studies of Visonhaler and of Edwards, laid the foundation for the major meta-analytic studies of the 80's.

"Kulik" is the name most frequently cited in the area of effectiveness studies. Their meta-analysis of 28 studies in the area of elementary CAI (Kulik, Kulik & Bangert-Drowns, 1985) was cited in 25 of the research articles and studies consulted for this review; it serves as the major support for the effectiveness of the computer and computer-assisted instruction as a unique and important teaching and learning tool in contemporary schools. The findings of this meta-analysis corroborated the earlier classic studies by Vinsonhaler and Suppes regarding the effectiveness of CAI. Their studies, spanning education from first grade through

college, have been primarily concerned with whether the computer could efficiently and non-reactively take over the delivery of drill and practice activities, freeing the classroom teacher to address higher level skills. Results of their elementary school meta-analysis indicate that:

1. CAI could bring about positive effects on the achievement of younger elementary students;
2. CAI could bring about substantial savings in instructional time (based on two studies);
3. CAI could bring about positive attitudes toward computers (based on 18 studies);
4. CAI could bring about better skills in reading, calculating, writing and problem solving in lower ability students.
5. CAI could bring about greater achievement in lower-ability students than in high ability students.

Based at Johns Hopkins University, Becker (1984, 1987a, 1987b, 1990) has been critic of CAI research. He faulted Kulik et. al. on their meta-analyses: 99% of their work was over systems and software that characterize 1%-2% of the software and hardware now in use; this criticism is also directed at Niemiec and Walberg's studies (Becker, 1987a, p.8). Decisions about how, when, and where to use micro-computers are different today than they were ten years ago. Drill and practice, the earliest form of CAI, was the easiest and cheapest to write. It was also the least creative use of educational computer technology, but currently still enjoys a strong place in American classrooms. In his current research, Becker considers a more appropriate line of

investigation to be determining how much more money we are willing to spend to achieve more efficient progress in mathematics (1984, p.33).

At the peak of the microcomputer wave hitting public schools in the mid-80's, Becker conducted a nation-wide survey to determine what student-computer ratios were at various levels of public education and for what purposes computers were used. His findings showed that the number of students per computer had been declining; this change in ratio was a response to parental demands for more and better computers rather than a clear or demonstrable educational advantages of using CAI. Fifty-six (56%) percent of elementary classrooms had a micro for use with drill. Beaver (1989) updated the survey and found that use in elementary schools had fallen to 40% nationwide. The top one-third of students (those scoring above the 66th percentile on standardized achievement tests) used them 45% of the time with boys and higher achievers dominating that use. Those who scored below the 34th percentile used them only 26% of the time. This disproportionate use of computers by high achievers contrasts to what research had been recommending: lower ability students reap the greatest educational gains from CAI.

Becker has strongly criticized the lack of longitudinal studies on CAI effectiveness; to correct that, he began a three-year CAI study in 1987 (Becker, 1990). Elementary

schools across the country were contacted, and interested schools committed to a two-year study; 56 teachers in 32 schools participated. Hurst Hills Elementary School in the Hurst-Euless-Bedford School District has just completed their part of the study with students in 5th and 6th grade mathematics classes.

Hurst Hills used a mathematics lab for supplemental instruction (27% of all elementary schools use a lab setup) with students who had scored below the 34th percentile on the SAT. In reporting results, Becker used the meta-analytic "effect size" measure. In the first year, the 5th grade achieved an effect size of +1.28, an enormous jump, which dropped to .03 in their 6th grade year; Becker attributed part of this disparity to the 50% transience of students. Of the 32 schools, Hurst Hills had among the highest and strongest average achievement gains; overall findings were significant and positive for the supplemental use of CAI. Findings addressed correlation, not causation. "It remains to discover what aspects of the implementation at Hurst were responsible for these large and reasonably consistent positive effects" (1990, p. 3). This question is being undertaken in Phase II of his research currently in-progress.

A strong debate exists in the literature regarding the appropriateness of how the computer is used in schools. One of Becker's purposes in conducting the 1985 survey was to

determine if American education had "matured" in its use of the computer for improving the effectiveness of our educational system. As mentioned above, the use of the computer as a means to provide drill and practice to students is regarded by some as not being a creative use of the medium. Salisbury (1985) agreed with other critics. A substantial part of the problem was due to the inferior nature of software; but "these poor examples should not cause us to underestimate the value of computer-based drill and practice" (p. 2). Sinatra (1986) traced this low level programming through the 1st, 2nd, and 3rd generations of software (corresponding to the first three generations of hardware), rating them primarily electronic skill workbooks. This view of drill as an abuse, misuse, or waste of current computer technology has roots in Benjamin Bloom's taxonomy of learning, which presents knowledge or recall as the first but lowest and least challenging level of cognitive learning.

Since learning is hierarchical, lower level learning is not trivial but the basis of higher level learning...Many lower level objectives are achieved only through repeated practice and feedback. (Vockell, 1988, p. 214)

While Becker advocates the use of the lab situation, as in Hurst Hills above, Sheingold, Khanne & Enrewelt (1983) felt most strongly that having the computers physically present in the classroom was the key to the success of

computer-assisted instruction. Sheingold contended that in order to be integrated into the curriculum computers must be used regularly and be part of the program, not an add-on, extra, reward; curriculum and computer must complement each other. It is easy to see how, having separate lab and no intentional teaching for transfer, Hativa (1988b) observed that the children in her sample had developed the notion that the arithmetic in class and the arithmetic at the computer were two completely different "entities" or concepts. She reviewed both media and discovered that the subject presentation was made very differently in each. Her conclusion was that in order for transfer to occur, computer-assisted instruction needs to be very much like classroom instruction in format.

Todd (1985) used fourth grade classes in four schools to measure the effect of CAI on achievement and attitude in mathematics and reading; her findings were mixed. Using the Iowa Test of Basic Skills, she determined a significant gain in mathematics achievement for students in the CAI groups compared to the control or traditional instruction groups. Positive attitudes of the experimental group were higher than the control, but there was no difference when compared by gender.

Confirming earlier studies, Roblyer (1985) reported that CAI was more effective with mathematics (over language arts and reading) but not at a statistically significant level.

While some computer applications have been demonstrated more effective for lower grades than for higher grades, her research departed from the mainstream and indicated that college CAI, not elementary, was most effective. Her research demonstrated no statistically significant correlation between CAI effectiveness and student gender.

Bass, Ries, Sharp (1986) focused on the use of the micro-computer used in the classroom under "regular classroom conditions" as compared to studies that used networks or lab situations. The target population was low achieving students in 4-6 grades; independent variables were mathematics and reading achievement. The experimental group in 4th grade did achieve significantly higher gains in mathematics as measured by pretests and post-tests; gains did not reach statistically significant levels for the 5th and 6th grades. This study was based on the representative design of R.E. Snow (1974): experiments reflecting real life learning environments versus a laboratory setting. A deficiency of this study was the non-equivalent control group design: having no control group for the 4th grade, where significant differences were found.

Bass, Ries, and Sharp make a case against the non-equivalence and invalidity of earlier research (such as Kulik, Burns, Visonhaler) which are dependent on mainframe or mini-frame technology. Differences between that technology and modern microcomputers make generalizations questionable.

Most of the software for early use was locally produced, not the higher quality commercially prepared software that we use today. Although not necessarily identified, variables in these studies included the software, the hardware, the personnel trained to operate the large systems with and their interaction effects. Many of these studies were pilot tests for prototype systems, very dissimilar to the micro-computer in today's classroom. While 27% of micro's are still in a lab configuration, all of the early studies were based on CAI taking place in a lab room separate from the classroom.

Hayes (1987) studied the effect of CAI used in a supplemental fashion with 6-8 grade students in a suburban school district; the control group did not use computers. Students in the experimental group achieved significantly higher gains in mathematics and reading. In comparing achievement against gender, subject socioeconomic level (SES), and ethnicity, no significant effects were found between mathematics achievement and these variables.

Tomberlin (1987) conducted a similar study, using only 6th graders, conducted over a six-week period, and only comparing mathematics achievement measured against the Alabama Basic Skills exam. In comparison of pre- and post-tests, he discovered no significant differences among any of his variables; this was unusual because most significant differences have been identified in short-term studies (less

the one semester). Perkins (1987) studied the effects of CAI on Michigan's basic skills mathematics achievement test and on student attitude toward mathematics and computers in 4th and 7th grades. Her results showed that CAI was a significant factor in 7th grader achievement ($p < .05$) and more so for 4th graders ($p < .01$). This finding is consistent with studies showing the effects of CAI diminishing with older students.

Chamberlain (1988) reviewed 38 recent research studies not covered in the Kulik meta-analysis; findings concluded that CAI remained a statistically significant teaching tool, but that when compared against teacher instruction, findings were ambiguous. A true discriminant in the studies surveyed was the ability of the teacher to incorporate the software into instruction in an "effective" manner.

Running through the psychology literature is a thread of research that investigates academic differences between genders and among ethnic groups. Wozencraft (1963) stated that to be valid, students of similar ability (i.e., high-achieving girls and high achieving boys) had to be compared; it was therefore invalid to compare the characteristics or abilities of high-achievers and low-achievers. Another critical variable in a valid mathematics study was student age; students in primary grades have shown fewer ability differences than students in high school or even junior

high. Kimball (1989) posed a third critical variable: the measure of achievement. If ability or performance were compared based on standardized tests, the most common finding in the research was that significant gender-related differences did not exist. When a difference had been found, girls scored higher on computation skills and boys excelled at problem solving and reasoning. When mathematics class grades were used as the measure of gender-related differences, the results were opposite of those found using standardized tests; differences almost always favor girls.

In an extensive work comparing the genders, Maccoby and Jacklin (1974) stated:

"There are four sex differences that are fairly well established...3) Boys excel in mathematics ability... but not until 12 or 13 when male math skills increase faster than girls' " (p. 352)

Bosner's (1910) early research comparing abilities of the genders addressed the "popularly held belief" that boys were better in mathematics than girls; he found "a small but real difference between the genders in mathematics ability favoring boys" (Wozencraft, p.486)

Stroud and Linguist (1942) conducted the first major gender-related mathematics study, which included over 50,000 subjects. Girls maintained a consistent and significant superiority over boys in all subject area tests, except in arithmetic; boys achieved small, insignificant gains

compared to girls across all mathematics skills. Reporting on research using differential psychological tests, Anastasi (1958) concluded that differences in numerical aptitude favored boys, but not until the late elementary, or early junior high years. Wozencraft (1963) confirmed that differences between the genders were fewer and less significant in 3rd grade than in 6th; but she concluded that girls were better than boys in arithmetic. Bright boys and girls were very similar to each other in ability as were slow-learning boys and girls; among average ability students, girls achieved higher than boys.

Benbow and Stanley (1981) confirmed that significant differences in mathematics aptitude and achievement begin in the 6th or 7th grade: in junior high girls showed a clear superiority in computation and boys in reasoning. Benbow and Stanley (1983) later clarified the distinction: reasoning ability develops before adolescence (in elementary grades) for boys, especially among high-achievers.

Applying the meta-analysis technique to gender-based research on mathematics ability, Carrier, Post, and Heck (1985) noted a shift in recent years: the ability of boys has remained fairly stable in grades 2 through 6, increasing slightly over the years; the performance of girls showed small improvements which increased more dramatically in later elementary grades. There was no difference between the genders in understanding concepts.

Approaching differences from a cultural perspective Moore and Smith (1987) analyzed the National Longitudinal Study of Youth Labor Force Behavior and concluded that as students progress through elementary school, mathematics has been stereotyped as a male domain. In elementary level mathematics knowledge, females out-performed males; in reasoning there was no difference. Large differences were discovered between White and Black students and between White and Hispanic students in grades K-8, a time when students generally experience a uniform exposure to subject matter. There was no significant difference between Black and Hispanic students K-8; both groups exhibited comparably low mathematics performance.

Black and Hispanic girls achieved higher scores than Black and Hispanic boys, but not at statistically significant levels. As students of all ethnic groups were given the opportunity to self-select courses in junior and senior high, fewer female students opted for mathematics courses because they perceived math as non-useful for them and because it was not relevant to their role as a woman.

Building on common sources, Matthews (1984) and Walberg (1984) developed models for increasing cognitive learning. While the Walberg model was generalized to all students, the Matthews model was oriented toward minority students. Among the factors that were critical to the participation and success of minority students in mathematics were:

- parent level of education and communication style,
- primary home language,
- student orientation toward achievement,
- student stereotyping,
- student language preference,
- student self-discipline and attendance
- class size

Attempting to explain the differences observed between the performance of boys and girls, Kimball (1989) looked at the environment of the mathematics classroom and concluded that boys "receive more of the teacher's attention, teachers interact with boys more than with girls and boys are more active in providing answers" (p. 201).

The bulk of CAI effectiveness research has been conducted on mainframes or minicomputers and for short durations (4 weeks or less). This study looks at computer use in the classroom for a full semester under normal conditions rather than in a computer lab. Subjects of this study are a new category of students: those identified at an early age as being at-risk of not completing their education due to a variety of variables. Individual performance is compared to state and district criteria rather than to national norms. The design is an experimental model, using random selection across a district and random assignment to treatment groups. The instruments used to measure achievement gain are correlated to state essential elements, district curriculum, state-adopted textbooks, and classroom software.

III. METHODOLOGY

A. Design

This study was modelled on Campbell and Stanley's experimental design 4 (Pre-test/Post-test Control Group Design), which controls for internal validity.

One-hundred fifty students were randomly selected from a population of 245 at-risk students and were randomly assigned to one of two treatment groups or a control group. All students were given a pre-test in December; following four months of the treatments, a post-test was administered in May to the students still residing in the district.

Hypothesis I stated that there would be no significant difference in the achievement gain scores of at-risk students who engaged in the standard CAI time, who engaged in "extended time" at CAI, or who engaged in extended mathematics time-on-task (H_1). Fifty students (25 boys and 25

HYPOTHESIS 1

STUDY DESIGN	MATHEMATICS TREATMENTS		
	REGULAR TIME	EXTENDED TIME	EXTENDED TOT
AT-RISK STUDENTS	n = 50	n = 50	n = 50

Table 1

girls) were randomly assigned to each of the treatment groups and to the control group. The achievement gain scores of each group were compared for statistically significant differences.

Hypothesis 2 stated that there would be no significant difference in the achievement of students of either gender in experimental groups (H_2). Each of the treatment groups and the control group were subdivided by gender; gain scores of each sub-group was compared for statistically significant differences.

HYPOTHESIS 2

STUDY DESIGN	MATHEMATICS TREATMENTS		
	REGULAR TIME	EXTENDED TIME	EXTENDED TOT
FEMALES AT-RISK	n = 25	n = 25	n = 25
MALES AT-RISK	n = 25	n = 25	n = 25

Table 2

B. Procedures

All students in the district engaged in computer drill, including the control group. The purpose of the current study was to see if doubling the amount of time engaged in CAI drill in mathematics would make a significant difference

in the mathematics achievement of at-risk students. While all students engaged in CAI, a random sample of at-risk students were assigned to engage in more (twice as much or approximately 60 minutes per week) CAI in mathematics, as in the Cranford study (1977). Another group engaged in an equal amount of math time-on-task in the form of worksheet activities comparable to those in the computer software. All students in class took a criterion-referenced exam in the late fall (serving as a pre-test measure) and an alternate form again in the spring (serving as a post-test) administered by their classroom teacher. Student progress was tracked during the course of the year for adherence to the CAI procedures as outlined for experimental groups (see Appendix B).

C. Sample

Using state education department agency criteria, the school district screened all students to identify those who were "at-risk" of failure. In accordance with university and district guidelines, letters were prepared describing the study and offering parents an option to deny permission to participate in the study; these letters were sent to the parents of all 5th grade students (see Appendix F). A list of 5th grade students identified as "at-risk" was obtained

from the district's Director of Pupil Personnel Services and from this list any student was deleted if parental permission to participate was denied. The list was divided by gender into two sampling frames (see Appendix A). Since names were arranged alphabetically, students were selected from across the district regardless of building or teacher; with low frequencies occurring in some classes and some buildings, neither of these factors was used as a variable.

Each gender list was subdivided into sampling units of five: twenty-three clusters of girls and twenty-seven clusters of boys. In each group, the first at-risk student (1) was assigned to the "standard time" control group; the third student (3) was assigned to the "extended time" experimental group; the fifth student (5) was assigned to the "extended time-on-task" experimental group, regardless of campus. Students assigned the number two (2) field tested the pre-test; students assigned the number four (4) field-tested the post-test. All students were coded by identification number.

D. Treatment

All students in the school district had access to a variety of drill and practice mathematics software for use with classroom Apple IIe's. The district drill and practice software available to each classroom included:

Adventures with Fractions, MECC
Essential Math - Add and Subtract, Berta-Max
Essential Math - Decimals, Berta-Max
Essential Math - Division, Berta-Max
Essential Math - Fractions, Berta-Max
Essential Math - Percent, Berta-Max
Essential Math - Number Concepts, Berta-Max
Grogin's Fractions, MECC
Speedway Math for Drill and Practice, MECC

The software was interactive, alerting a student when an error has been made, offering the opportunity for a second attempt, and providing the correct answer for reinforcement (see Appendix C). The software was also gender-neutral (i.e., not containing graphics depicting boys or girls). All students in the study were exposed to the same software and allowed to self-select software appropriate to their classroom instruction. Teachers were informed which of their students were in experimental groups. By arrangement with building principals, the researcher met separately with students assigned to each of the experimental groups in their school in order to explain the task of that group in the study; these meetings took place during teacher conference periods. As Tanner (1980) recommended, elementary students, told individually what they need and how best to achieve that objective, will perform better than those left to seek their own goal or method of achieving that goal.

From December to the middle of May, teachers monitored student progress (see also Appendix B). Teachers attended an in-service covering:

- standardized presentation of the test;
- standardized student access to computers during non-instructional time;
- providing independent practice for students;
- availability as a mentor to students experiencing difficulty.

As recommended by Shaver (1983) and Vitchoff (1988) in models for supervision of experimental research, the researcher monitored classrooms to check that: teachers were consistent with the model of supervision, they scheduled computer time, and students were following guidelines. As recommended in the literature (Sheingold, Khamne & Enrewelt, 1984; Bass, Ries, Sharp, 1986) the natural setting of the regular classroom was used rather than a computer lab.

During the normal school day (8 AM - 3 PM), students engaged in CAI on a rotation basis: every student had the opportunity for standard computer time in a rotational order. As described in above, one group engaged in an extended period of CAI time. To allow for this "extra" time, students in this experimental group were allowed to get CAI time whenever they completed assignments, when the rest of the class was not engaged in mathematics, and when the equipment was free. These times were sometimes just before or just after school, while other students were engaged in reading groups or in other types of independent practice [homework]. Likewise, those engaged in the second experimental group, extended mathematics time-on-task, spent an equal amount of time on paper and pencil math activities

similar to those contained in the software (see Appendix G). They took advantage of "free time" as described above for the extended computer time group.

The issue of time as a variable has been addressed in a variety of ways in the literature. While effective schools research suggests math instruction/time-on-task requires a daily engagement time of 15-45 minutes in order for students to perform at grade level (Squires, n.d.), clock time-on-task is not the same as computer time-on-task. Rupe (1986) calls this efficiency the "computer-assisted instruction phenomenon". The efficiency of time spent at the computer (i.e., students taking less time to learn the same content as compared to conventional instruction) is a trend in CAI effectiveness research (Edwards, 1974; Kulik, 1983; Roblyer, 1985; Baron 1986). Reasons to differentiate real time and computer time include: immediate feedback, instruction at individualized levels, individualized pace, and the positive attitude that is fostered by CAI (Baron, 1986; Lepper, 1985).

No accepted standard for CAI time related to mathematics achievement has been established in the literature. While many studies have not controlled for time, some trends are indicated. Hotard (1988) established a critical value of 18 minutes per week as the minimum CAI time necessary to make a significant impact on achievement of Title I students and 30

minutes per week as an "ideal" time. Becker (1990) cited 7 minutes per day as a standard, Gilman and Brantley (1988) 5 minutes per day, Vinsonhaler (1974) 5-15 minutes per day, Lysiak (1976) and DelForge and Clark (1989) 10 minutes per day, and Bass (1986) 20 minutes per week. Baron (1986) found no statistical difference between 30, 60, and 90 minutes of CAI per week. Following the current Becker model, a standard CAI time of 30 minutes per week was used for all students in all classes. The extended computer time group had an extra thirty minutes per week of CAI, a total of sixty minutes per week.

E. Instrumentation

In 1985 a committee of mathematics specialists and curriculum staff in the school district used for this study established content validity for a set of district criterion-referenced exams. Exams were field tested within the district, resulting in a set of tests for each grade level, Mastery Tests of Curriculum Objectives: (Carrollton-Farmers Branch I. S. D., [1986]) and an estimated reliability factor ($r_e = .9$). These tests consisted of four questions related to each state-identified essential element. For this study a district test was selected rather than a standardized one because it was correlated to the state essential skills, the state-adopted text, and the software in every classroom.

In the pre-test, clusters of 14 skills were identified within the test; two questions were randomly selected for each skill. A field test of the pre-test was done using students not chosen for the experimental or the control groups (the "2" from each cluster or sampling unit in the sampling frame). A Kuder-Richardson formula (K-R 20) applied to the test resulted in a coefficient of internal consistency equal to .87; a K-R 21 resulted in an $r_{cic} = .81$. The test was distributed to each of the campuses and administered by classroom teachers; students used Scantron sheets to record their answers.

The remaining "half" of the questions from the district test were field tested during the study. A reliability coefficient of $> \text{ or } = .8$ had been established as acceptable; A Kuder-Richardson formula (K-R 20) applied to the post-test resulted in a coefficient of internal consistency of $r_{cic} = .93$. Subsequently, the post-test was distributed to participating teachers and administered in mid-May.

F. Data collection

Students in the regular-time (control) CAI group and the extended computer time group logged on and off computers daily. Students in the extended time-on-task/workbook group were assigned a guideline of completing and checking one to two pages in Electric Math per day (see Appendix G for

examples) or ten minutes of time-on-task; based on a consensus of classroom teachers, this corresponded to the extra computer time of the other experimental group. Logs and workbooks were monitored weekly by teachers to assure that both experimental groups had the appropriate engagement time. Students in these groups were tracked for one semester (December through mid-May). Work-sheets from students in the extended mathematics time-on-task group were monitored weekly by teachers and were collected monthly by this researcher; results were returned to the students. The computer group averaged 10.25 minutes per day of computer above the class norm. Students assigned to the extended time-on-task (workbook) treatment completed and checked an average of 78.2 pages in their books during the study.

The criterion-referenced tests were administered by classroom teachers and scored on a Scantron 881. Results for each student taking each test were shared with teachers; percentage of correct responses, pre-test and post-test scores, and gain percentages were reported. Mathematics skills were divided into 14 sub-skill areas in order to provide useful feedback to teachers regarding student progress as well as for inclusion in this study (Appendix H).

IV. ANALYSIS OF DATA

A. Reporting the Data

Students were randomly selected for the study in October and all 5th graders took the pre-test in December. Due to family mobility, a number of students who were initially selected did not complete the study. Of the 150 students selected for the study in October, 119 students (55 girls, 64 boys) completed the study, taking both pre-test and post-test (see Appendix H). Three students were eliminated for failure to follow guidelines.

GENDER	TREATMENT	MODEL	10/90	5/90
FEMALE	Computer	25	23	19
	Workbook	25	23	18
	Control	25	23	18
MALE	Computer	25	27	21
	Workbook	25	27	21
	Control	25	27	22

N = 150 N = 150 N = 117

Table 3

In order to determine whether there was a significant difference in groups that were sampled, an ANOVA was performed on pre-test scores for treatment groups.

ANOVA SUMMARY 1 - PRE-TEST MEANS SCORES				
Variation	Df	S.S.	M. S.	F
Between	2	269.20	134.60	1.15
Within	116	13634.26	117.54	
Total	118	13903.46		p < .2

Table 4

An F equal to 2.70 was required for significance at the .05 level ($df_b = 2$, $df_w = 116$). Since the F obtained was only 1.15, the difference among means was not significant for this group of samples and therefore these groups were considered similar.

The mean score for boys on the pre-test was 44.64 and for girls was 41.24. A t -test was performed on student pre-test scores according to the gender groups; this was done as above in order to determine if there were significant differences in these two samples. The critical value for $df = 120$ was 1.98; the ratio obtained from the t -test for the two samples was 1.38. When student scores were compared by gender groupings, the means for the two samples were not significantly different, and they were considered similar.

Students in the workbook group achieved the highest mean score on the pre-test and had the largest variance. While the workbook mean score on the post-test was not as large as the computer mean score (Table 5), workbook group variance

TEST SCORE MEANS, GAIN SCORES, AND STANDARD DEVIATIONS BY INDEPENDENT VARIABLES

TREATMENT	N	PRE-		TEST		POST-		TEST		GAIN	
		MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.		
T1: COMPUTER	40	42.25	9.01	60.88	12.26	18.63	11.86				
T2: WORKBOOK	39	45.20	13.70	54.74	14.13	9.54	9.46				
C: CONTROL	40	41.80	9.25	46.73	13.02	4.93	10.13				
TOTAL	117	43.07	10.86	54.11	14.29	11.04	11.92				

Table 5

Maximum Score Possible 100

TREATMNT	N	PRE-		TEST		POST-		TEST		GAIN	
		MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.		
G	19	41.95	9.67	57.58	13.83	15.632	12.924				
I	18	42.78	11.93	54.72	11.39	11.944	8.516				
R	18	38.94	7.41	47.89	14.02	8.944	11.294				
L	55	41.24	9.80	53.47	13.54	12.236	11.241				
B	21	42.52	8.60	63.86	10.06	21.333	10.389				
O	21	47.29	15.02	54.76	16.40	7.476	9.933				
Y	22	44.14	10.09	45.77	12.40	1.637	7.883				
TOT	64	44.64	11.53	54.66	14.98	10.016	12.477				
GRAND MEAN		42.94		54.06		11.13					

Table 6

remained the largest. The control group had the lowest mean scores but the variance of these scores was at neither extreme. The pre-test mean for the extended computer time group was lower than the pre-test mean for the extended time-on-task/workbook group. On the post-test, this order reversed itself, and the gain score mean for the computer group was almost twice as large as for the workbook group.

The pre-test grand mean was 42.94. When pre-test scores were grouped by gender, the mean for boys (44.64) was higher than the mean for girls (41.24); the variance was greater for boys ($s = 11.53$) than for girls ($s = 9.8$); the deviation score was $/1.7/$. Post-test means were much closer to the post-test grand mean (54.06); the deviation score was $/.59/$.

When scores were broken down by treatment and gender (see Table 6) some differences were noted:

1. The largest variance was found in the workbook treatment on both pre- and post-tests (Table 5); when post-test scores were broken down by gender, girls had the smallest standard deviation and boys the largest among their respective groups.
2. On pre-tests, the group scoring lowest among boys was the computer group and among girls the control group; each also had the lowest variance of scores in their variable grouping. Conversely, girls in the workbook group had the highest mean score and greatest variance.

3. Post-test mean scores ranked the same by treatment-only and by treatment and gender. Standard deviation did not follow that pattern: girls in the workbook group had the smallest variation while workbook group showed the largest variation among the male groups.
4. Gain scores and standard deviation among female groups followed the rankings of the treatment-only scores. Among the boys the smallest standard deviation was in the control group; the mean gain score of 1.637 would explain the small variation.

B. Testing the Hypotheses

The hypotheses of the study addressed mathematics achievement of at-risk 5th grade students in two experimental groups and a control group.

Hypothesis 1: There will be no significant difference between the achievement gain scores of at-risk students who engage in the standard CAI time, who engage in "extended time" at CAI, or who engage in extended mathematics time-on-task (H_1).

An ANOVA was performed on pre- and post-test gain scores of the three groups. The level of significance for H_1 was set at $p < .05$; the actual level of significance was $p < .0001$ (Table 7). Therefore the null hypothesis was rejected.

ANOVA GAIN SCORES FOR TOTAL SAMPLE

TREATMENT	N	MEAN	STANDARD DEV.	
Computer	40	18.63	11.86	
Workbook	39	9.54	9.46	
Control	40	4.93	10.13	
Anova Summary - 2				
Variation	Df	S.S.	M.S.	F
Between	2	3884.95	1942.47	17.48
Within	116	12891.84	111.14	
Total	118	16776.79		p<.0001

Table 7

Analysis of variance tests were performed between means. Comparing computer gain scores to control gain scores resulted in $F = 33.77$ ($p < .0001$), indicating significant difference between means of computer group students and control group students. Gain scores of the computer group compared to gain scores of the workbook group resulted in $F = 14.67$ ($p < .0002$), indicating significant differences between extended computer time and extended mathematics time-on-task. T-tests were also computed for means and showed the similar results. Using the Scheffé method of multiple comparison the same results were reached. Comparison of computer and control groups was significant at $p < .01$ as was comparison of computer and workbook groups. Comparison of workbook and control groups did not yield statis-

tically significant results.

SCHEFFÉ MULTIPLE COMPARISON OF MEANS

	COMPUTER	WORKBOOK	CONTROL	
TREATMENT	I	II	III	
CELL	FACTOR	F	F' α =.05	F' α =.01
I, II	COMPUTER/CONTROL	22.32	6.14	9.56
I, III	COMPUTER/WORKBOOK	14.67	6.14	9.56

Table 8

Hypothesis 2: There will be no significant difference in the achievement of students of either gender in experimental groups (H_2).

ANOVA GAIN SCORES BY GENDER-FEMALE

TREATMENT	N	MEAN	STANDARD DEV.	
Computer	19	15.63	12.92	
Workbook	18	11.94	8.52	
Control	18	8.94	11.30	
Anova Summary - 3				
Source of Variation	Df	Sum of Squares	Mean Square	F
Between	2	415.62	207.81	1.69
Within	52	6408.31	123.24	
Total	54	6823.93		p < .2

Table 9

In Table 9, the critical value of F ($df_b = 2, df_u = 52$) was 3.18. Since $F = 1.69$ in the ANOVA for treatments among female students, the null hypothesis for H_2 was retained for girls; there was no significant difference in mean scores among the three groups. A power test was performed to make a post hoc estimate of Type II error. The computed power was .86 for this size sample; .80 is acceptable measure (Burns and Grove, 1987).

ANOVA GAIN SCORES BY GENDER - MALE

TREATMENT	N	MEAN	STANDARD DEV.
Computer	21	21.33	10.39
Workbook	21	7.48	9.93
Control	22	1.64	7.88
Anova Summary - 4			
Variation	Df	S.S.	F
Between	2	4369.99	21.99
Within	61	5437.	89.13
Total	63	9806.98	p < .05

Table 10

In Table 10, the critical value of F ($df_b = 2, df_u = 61$) for the .05 level of significance was 3.15. Since $F = 24.51$ in the analysis of variance for treatments among the male students, the null hypothesis for H_2 was rejected for boys. The difference in mean scores among the three groups of boys

was statistically significant at $p < .0001$ level.

Because of this difference, means were compared using analysis of variance; three significant pairs resulted (Table 11). There was a significant difference between means of boys' computer and control groups; boys' workbook and control groups; and the boys' workbook and computer groups. T-tests were also computed and showed similar results.

ANOVA 5 - TREATMENT GROUP COMPARISONS - MALES

TREATMENT	CRITICAL F	F RATIO	SIGNIFICANCE
Computer/Control	4.09	46.77	$p < .0001$
Workbook/Control	4.09	4.11	$p < .05$
Computer/Workbook	4.08	22.62	$p < .0001$

Table 11

To test these differences at a more conservative level, a Scheffé multiple comparison was administered (Table 12). Significant differences were present at $p < .01$ for comparisons of boys' computer and control groups and for comparisons of boys' computer and workbook groups; the failure of the third comparison to reach the .05 level of significance is most probably due to the conservative nature of the Scheffé method. For the purposes of this study, the difference found in the means between the boys' workbook and the computer groups is the difference with the greatest bearing

on implications for use in education.

SCHEFFÉ MULTIPLE COMPARISON OF MEANS - MALE TREATMENT GROUPS

	COMPUTER	WORKBOOK	CONTROL	
BOYS	I	II	III	
CELL	FACTOR	F	F' α =.05	F' α =.01
I, II	COMPUTER/CONTROL	22.32	6.14	9.56
I, III	COMPUTER/WORKBOOK	14.67	6.14	9.56

Table 12

A two-way ANOVA was performed on means for treatment and for gender groups; the ANOVA resulted in three F ratios (Table 13). For genders, the critical value of F at the $\alpha = .05$ level of significance ($df_p = 1$, $df_u = 113$) is 3.92; since the F ratio for gender was $F = 1.16$, there was no significant difference in means (see Table 9). For treatment, the critical value of F at the $\alpha = .05$ level of significance ($df_p = 2$, $df_u = 113$) is 3.07; since the F ratio for treatment was $F = 16.95$, there was a significant difference in the means. For interaction, the critical value of F at the $\alpha = .05$ level of significance ($df_p = 2$, $df_u = 113$) is 3.07; since the F ratio for interaction of gender and treatment was $F = 4.94$, there was significant difference in means.

ANOVA 6 - TWO-FACTOR ANALYSIS OF VARIANCE

TREATMENT	N	MEAN	S.D.	
Females - Computer	19	15.63	12.92	
Females - Workbook	18	11.94	2.52	
Females - Control	18	8.94	11.3	
Males - Computer	21	21.33	10.39	
Males - Workbook	21	7.48	9.93	
Males - Control	22	1.64	7.88	
Anova Summary - 5				
Variation	Df	S.S.	M. S.	F
Gender	1	121.21	121.21	1.16
Treatment	2	3554.34	1777.17	16.95
Interaction	2	922.2	461.10	4.40
Within/Error	113	11845.31	104.83	
TOTAL	118	16443.06		

Table 13

A Scheffé comparison test (Table 14) was performed on combinations of all means. This procedure resulted in eight significant mean differences, five of them at $p < .01$ level of significance. Students in the four treatment groups scored significantly higher than the boys in the control group. Both the boys and the girls in the computer groups scored significantly higher than the boys using workbook. As demonstrated (see Table 12), the boys in the computer

group scored significantly higher than the boys in the workbook or in the control group. Perhaps due to the rigor of the Scheffé, the significant difference that resulted from a t-test applied to gain scores of girls' computer group and the girls' control group did not hold true for the multiple comparison.

SCHEFFÉ MULTIPLE COMPARISON OF MEANS

	COMPUTER	WORKBOOK	CONTROL
FEMALE	I	II	III
MALE	IV	V	VI

CELL	FACTOR	F	F' α =.05	F' α =.01
I, VI	GIRLS/COMPUTER BOYS/CONTROL	19.05		9.64
I, V	GIRLS/COMPUTER BOYS/WORKBOOK	6.33	6.18	
III, IV	GIRLS/CONTROL BOYS/COMPUTER	14.19		9.64
II, IV	GIRLS/WORKBOOK BOYS/COMPUTER	8.15	6.18	
II, VI	GIRLS/WORKBOOK BOYS/CONTROL	10.03		9.64
IV, VI	BOYS/COMPUTER BOYS/CONTROL	39.76		9.64
IV, V	BOYS/COMPUTER BOYS/WORKBOOK	19.68		9.64
V, VI	BOYS/WORKBOOK BOYS/CONTROL	7.06	6.18	

Table 14

C. Other Differences

In comparing scores on pre-tests and post-tests, gains were used as the measure of success and achievement. When looking at the scores by groups (Tables 16-18), it was of interest to note the range of scores and their absolute values in relation to mastery of the essential elements. The maximum score possible on pre-test or post-test was 100.

RANGE OF SCORES - PRE-TEST AND POST-TEST

	FEMALES PRE-TEST	FEMALES POST-TEST	MALES PRE-TEST	MALES POST-TEST
COMPUTER	23-59	37-81	30-59	51-83
WORKBOOK	20-66	26-75	31-93	24-96
CONTROL	26-55	26-78	32-61	25-75

TABLE 15

The measure of skills mastery within the district and the state is 70%. As might be expected, there was a wide range of scores on the pre-test from 20-70 with one extreme score of 93. Despite four months of additional instruction and the extra time-on-task by the two treatment groups, student failure to master the essential elements of 5th grade mathematics continued to be high on the post-test.

No students in the computer groups scored above 59 on the pretest. On the post-test, 27.5% of the students achieved

mastery; that translated into 26% (5/19) of the girls and 29% (6/21) of the boys scoring at the mastery level. Two boys in the workbook group demonstrated mastery on the pre-test and went on to score higher on the second test; one of these boys achieved at a consistently high level (93/96) and inclusion of his scores distorted the range of scores as reported for the boys' workbook group. On the post-test, 15% of the students in the workbook group scored above 70: 11% (2/18) of girls and 19% (4/21) of the boys. No students in the control group showed mastery on the pre-test; on the post-test, only 10% of the students scored above 70%: 17% (3/18) of the girls and only 5% (1/22) of the boys). If the two boys who demonstrated mastery on the pre-test were eliminated, 17% of the students (19/117) involved in the study mastered the essential elements of the 5th grade mathematics curriculum; of those involved in treatments, 22% mastered 5th grade mathematics objectives.

Some of the individual gains presented in Tables 16-18 were impressive: in the computer groups, one girl improved her pre-test score by 131% and one of the boys by 165%. In the control group, almost 40% of the students had negative gain scores and one boy and one girl demonstrated mastery, the girl improving by 81%. Despite these and other large gains in the computer treatment, the fact remains that only 27.5% of the extended computer time students mastered the mathematics objectives.

Current research on mathematics achievement based on gender differences has found no significant differences between genders in ability, but when non-statistical differences have been found, girls have excelled over boys, especially in the area of computation. These skills were:

- whole number value (Graph 1)
- computation of whole numbers (Graph 2)
- whole number word problems (Graph 3)
- graphs (Graph 4)
- estimation (Graph 5)
- area (Graph 6)
- other measurement (Graph 7)
- exponents (Graph 8)
- fraction value (Graph 9)
- computation of fractions (Graph 10)
- least common multiple (Graph 11)
- probability (Graph 12)
- decimal value (Graph 13)
- computation of decimals (Graphs 14)

Charts 1-14 (Appendix H) show gain score frequencies by sub-skill. Investigation of these distributions showed a consistent tendency of sub-skill gain scores to approximate the normal curve; the one exception was computation of whole numbers, which was negatively skewed and showed regression, or loss of skill. When the frequencies were charted by sub-skill and gender, the gain scores of girls failed to conform to the findings presented in the literature: that there would be no differences or that girls would out-perform boys in computation skills. The only computation skill in which girls did out-perform boys was in computation of decimals, but only by a slight margin (4 students). Boys achieved higher scores in computation of whole numbers and fractions.

STUDENT SCORES - EXTENDED COMPUTER TIME TREATMENT

FEMALE STUDENTS				MALES STUDENTS			
STU.	PRE	POST	GAIN	STU.	PRE	POST	GAIN
1	44	37	-7	20	30	54	24
2	42	46	4	21	44	55	11
3	53	50	-3	22	45	73	28
4	35	48	13	23	47	60	13
5	38	51	13	24	31	82	51
6	48	58	10	25	41	63	22
7	32	74	42	26	51	64	13
8	59	75	16	27	40	64	24
9	35	81	46	28	31	54	23
10	48	57	9	29	57	65	8
11	23	39	16	30	46	53	7
12	26	38	12	31	34	53	19
13	40	57	17	32	44	51	7
14	48	60	12	33	59	83	24
15	56	81	25	34	35	66	31
16	41	53	12	35	47	70	23
17	54	62	8	36	57	76	19
18	45	70	25	37	41	60	19
19	38	55	17	38	33	62	29
				39	48	80	32
				40	43	54	11

Table 16

SCORES: EXTENDED TIME-ON TASK/WORKBOOK TREATMENT

FEMALE STUDENTS				MALES STUDENTS			
STU.	PRE	POST	GAIN	STU.	PRE	POST	GAIN
41	32	62	30	59	33	50	17
42	47	56	9	60	70	80	10
43	35	61	26	61	31	30	-1
44	54	70	16	62	53	65	12
45	38	46	8	63	53	52	-1
46	66	63	-3	64	49	51	2
47	45	61	16	65	33	47	14
48	43	52	9	66	43	48	5
49	53	64	11	67	60	75	15
50	61	55	-6	68	35	46	11
51	43	52	9	69	65	71	6
52	58	75	17	70	33	50	17
53	20	26	6	71	93	96	3
54	23	41	18	72	44	57	13
55	47	51	4	73	57	61	4
56	27	44	17	74	43	55	12
57	45	48	3	75	33	40	7
58	49	43	-6	76	44	67	23
				77	39	42	3
				78	39	48	9
				79	51	24	-27

Table 17

STUDENT SCORES - CONTROL (C)

FEMALE STUDENTS				MALES STUDENTS			
STU.	PRE	POST	GAIN	STU.	PRE	POST	GAIN
80	49	51	-2	98	61	75	14
81	43	78	35	99	61	59	-2
82	39	26	-13	100	46	54	8
83	45	43	-2	101	35	43	8
84	36	57	21	102	37	39	2
85	39	40	1	103	36	35	-1
86	41	46	5	104	56	48	-8
87	41	49	8	105	48	49	1
88	55	70	15	106	35	33	-2
89	42	59	17	107	49	25	-24
90	43	70	27	108	36	57	21
91	29	47	18	109	52	51	-1
92	33	39	6	110	45	42	-3
93	39	41	2	111	51	49	-2
94	34	39	5	112	47	46	-1
95	27	33	6	113	32	42	10
96	43	46	3	114	39	29	-10
97	26	35	9	115	52	50	-2
				116	45	47	2
				117	32	36	4
				118	33	30	-3
				119	51	58	7

Table 18

D. Discussion

One result of the research done in this study demonstrated that a small amount of easily-lost time--ten minutes each day when direct instruction was not taking place and other learning tasks had been completed--could make a significant difference in the skills achievement of some at-risk students. This finding suggests the different nature of time engaged interacting with a computer and receiving immediate feedback through the electronic medium. Students engaged in real-time workbook activities, although receiving a similar immediate feedback by consulting the teacher's edition of the workbook, did not experience the same level of success as the computer group; such success would have been demonstrated by achieving comparable gain scores.

During our initial meetings in mid-October and early November, a number of teachers indicated that they had not yet "fired-up" the computers for the school year. It would therefore seem that among the repertory of teaching strategies, this activity did not rate high on the list of priorities, perhaps because use of computers in the classroom is not perceived as important as more traditional learning activities or does not have a high level of visibility. While parents notice when students are not having tests or not getting homework, they may not think to ask how their child is doing at the classroom computer center.

Based on this study, productive time for at-risk students to be engaged in CAI was lost during these seven or eight weeks when it was unavailable to these children. Although the allocation of funds or commitment to embark on a program of CAI may be a district-level decision, successful implementation at the campus level rests ultimately with the principal as instructional leader. From the administrative perspective, this is an area that may need to be monitored in order to determine that teachers know how to effectively and efficiently use these expensive and limited resources in their classrooms and how to integrate them into the curriculum and the normal routine.

As presented in the preceding discussion, use of computers in the classroom is seen as a function of instructional leadership, financially-based administrative/management decisions, and teachers' commitment and ability to incorporate their active use into the curriculum. Given limited resources available at this time, a principal may need to choose between a laboratory configuration for the microcomputers to be available to an entire building or to have computers decentralized in classroom computer centers. The results of this study indicate that allocation of computers to classrooms where at-risk students are dispersed or where a greater number of at-risk students might exist combined with immediate access and monitoring their use and incorpo-

ration into the curriculum can result in increased gains for this part of the student population.

As cited in Chapter I, drill and practice has not been highly regarded in the computer literature during recent years because it represents a low level of activity on the hierarchy of cognitive skills; nevertheless, with the population of at-risk students used in this study, extended use of CAI appeared to help these students to achieve significant gains over extra time on paper and pencil activities. Comparison of drill and practice to other types of CAI (simulation, tutorial, higher order thinking) is beyond the scope of this study but is a natural extension of this study. In the current study it has been demonstrated that use of this low-level activity by a special population resulted in some large gains for individuals and for the experimental group of boys in general.

Throughout this century research has failed to demonstrate gender-based differences in mathematics (Bosner, 1910; Stroud & Linguist, 1942; Anastasi, 1958; Wozencraft, 1964; Maccoby, 1974; Kimball, 1989). Failure of the current study to demonstrate significant differences between gender groups engaged in the same treatment was simply a validation of previous research, but with extended application to a special population, at-risk students.

When considering the body of research which has found the use of computer-assisted instruction to be effective in achieving significant differences or gain scores (Benbow, 1981, 1982; Burns & Bozeman, 1981; Kulik, 1983, 1984; Kulik, Kulik & Bangert-Drowns, 1985; Roblyer, 1985; Todd, 1985; Salomon, 1986; Becker, 1987b; Hayes, 1987; Lepper, 1989), it was surprising to find no significant differences in the female groups.

Although application of a t-test to means of female computer and control groups indicated a significant difference, it was not a strong enough difference to withstand the rigor of a Scheffé test. No significant difference was discovered between the computer group and the workbook group. Scores for boys in treatment groups tended to cluster around a small range in the pre-test and increased cohort-style on the post-test; the range of post-test scores for girls in both treatment groups simply got larger, representing increased variation and less of a trend. Why were the scores so heterogeneous and the groups so comparable? Does it have to do with teachers giving more attention to boys (Kimball, 1989)? Although the literature offered no grounds for explaining this failure of treatment groups to differ significantly, there are some variables which might have affected the results of this study.

Many CAI studies have used attitude toward school and the academic subject as a variable when investigating effective-

ness and have found a high correlation between achievement and positive attitude toward mathematics (Vinsonhaller & Bass, 1972; Jamison, Suppes & Wells, 1974; Kulik, Kulik & Bangert-Drowns, 1985; Todd, 1985). Inclusion of this factor in future at-risk studies might clarify findings similar to those in the current study. Motivation (Kloosterman, 1990) and support within the family (Matthews, 1984; Walberg, 1984), cognitive ability (Anastasi, 1958), effort (Matthews, 1984), and the perceived relevance of mathematics in the life of an at-risk girl (Moore & Smith, 1987) are possible factors affecting mathematics achievement. The concept of working alone, in isolation from one's peers, has been covered extensively in the research done on cooperative learning (Johnson, Johnson & Holubec, 1991); this isolation may also be a factor that deters girls from a higher degree of mathematics achievement. Since the at-risk student is a fairly new category under study, findings of the current study may be due to characteristics common among at-risk girls. A possible research hypothesis might state that girls who have been identified as at-risk do not respond to drill and practice activities, regardless of the delivery system, or have low motivation to achieve in mathematics, or have a negative attitude toward mathematics.

The question may be raised that although this study has demonstrated significant gains for at-risk students engaged

in extra computer time, were these gains "enough"? Did these gains help students in turn to achieve passing grades in mathematics? It not known what mathematics grades students participating in the study took home with them at the end of the school year or how many were successful in passing mathematics. In Chapter II, the reciprocal relationship that exists between standardized tests and mathematics class grades was discussed: students that did well on standardized tests tended not to do well in their mathematics class grades. Investigation of a possible correlation between mathematics grades of at-risk students and achievement as measured on a standardized instrument would be a natural extension of the current study. Despite the provocative nature of this question, it is necessary to put this study back into the context of its original intent: to determine if extended use of computer-assisted instruction would help at-risk students to make significant gains in mathematics. If the answer to this research question proved to be true, then extended CAI time could be used as one of a variety of strategies to help prevent failure in at-risk students.

V. SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS, AND
RECOMMENDATIONS FOR FURTHER STUDY

A. Summary

In the last few years, students labelled "at-risk" of failure have become the focus of national attention and concern. The "at-risk" category has been broadened beyond low ability students to also include those who: have failed multiple courses, are unmotivated, are from low socio-economic backgrounds, have high absentee rates, are associated with gangs, have been abused, or have limited English proficiency. All students, beginning in primary grades, are now the focus of concern and intervention, not just high school drop-outs. A federal mandate calls for the educational community and the states to take a holistic approach to the at-risk problem and to evaluating early identification and intervention strategies.

While failure has always been a cause for concern, the problem is now a cause of national concern and mobilization of resources. Criteria have been set in place to help identify students as early as first grade and allow interventions to be put in place, evaluated periodically, and be updated. Nevertheless, the drop-out rate remains enormous

and continues to challenge the educational community to prevent student failure. This study presents one strategy aimed at reducing the rate of failure.

Over the last ten years, research on microcomputers in schools has demonstrated the effectiveness of CAI combined with conventional instruction over traditional classroom presentation of subject matter for low achieving students. A small part of that research has investigated microcomputers in the classroom. The basic questions in this current study were: 1) would larger amounts of CAI help at-risk students to significantly improve their mathematics skills; and 2) would there be a significant difference between the mathematics achievement of boys and girls in different time-on-task groups.

An equal number of boys and girls were randomly selected across the district from the total fifth grade pool of 255 students who had been identified by the district as "at-risk". Each of the students was randomly assigned to a computer group (extra computer time), a workbook group (extra independent mathematics time-on-task), or a control group. Teachers participated in an in-service regarding standardized administration of the treatments in their classroom and of the pre- and post-tests.

Students assigned to each group attended separate orientations where they learned their role and how best to carry out that task during the four-month study. Students in the

computer group were instructed about the time required to participate successfully; they received time logs and had the same set of district-supplied software available for use in every district classroom. Students in the workbook groups received a workbook designed to correlate to the curriculum and to the software; they were instructed about daily time requirements and encouraged to self-correct using the teacher's edition workbook. Time logs and workbooks were monitored on a daily basis by teachers and every three weeks by the researcher; scores of students not following guidelines were removed from consideration in the results.

In December a district criterion-referenced mathematics skills pre-test was administered by all 5th grade classroom teachers in 13 schools; in May an alternate form was given as a post-test. Both forms had been field-tested with at-risk students and received an $r_{cic} > .9$; a reliability coefficient greater than .8 is acceptable. Following the post-test, statistics were calculated using the Stat-Pack Gold statistical program for one-way and two-way analysis of variance; significant differences were compared using the Scheffé Multiple Comparison method.

B. Findings

The analyses of variance revealed that there were significant differences among means of the three treatment

groups and two gender groups. Score and gain means were compared using analyses of variance and Scheffé Multiple Comparisons for significant differences. One test failed to find a significant difference. The findings addressed the hypotheses in the following way:

1. There was a significant difference in student achievement among the treatment groups. The students in the computer group achieved significantly larger gain scores than students in the control group. Students in the computer group also achieved significantly larger gain scores than students in the workbook group.
2. Comparison of means for boys in the three groups yielded significant differences. Applying a Scheffé comparison to gain scores showed significantly larger gains for boys in the computer group than for boys in the control group. Scores for boys in the computer group were also significantly larger than scores for boys in the workbook group.
3. There was not a significant difference in scores among girls in the three groups. When the two-factor ANOVA was calculated and t-tests were applied to means, a significant difference resulted between the gain scores of girls in the computer group and girls in the control group ($p < .05$). This significant difference did not withstand application of a Scheffé; failure to

do so may be attributed to the conservative nature of this comparison method.

4. The lack of any significance between comparable groups of students by gender (i.e., boys' computer group versus girls' computer group) confirmed findings in the literature that no significant differences exist in mathematics abilities between boys and girls. Had any non-statistical difference been found, it should have favored girls, especially in the area of computation. In the current study, girls out-performed boys only in the computation of decimals; boys outperformed girls in computation of whole numbers and fractions.

C. Conclusions

1. Students engaged in additional time-on-task can achieve significantly higher scores than those not engaged in extra time-on-task.
2. At-risk students, especially boys, can achieve higher gain scores by spending 10 minutes per day engaged in mathematics computer-assisted instruction.
3. The quality of time-on-task in mathematics makes a difference in the amount of gains achieved by at-risk students. Students can achieve greater gains in mathematics basic skills using computers than they can using

workbooks. Boys in particular can achieve significantly higher scores using CAI over paper and pencil activities. Girls can also achieve higher scores, but not at statistically significant levels.

4. Based on the results of this study, at-risk girls can make comparable gains in mathematics skills regardless of the method of delivery. While all students are entitled and required to engage in computer time, extended amounts of time using this delivery system do not substantially help girls to achieve any better.

5. In the public school system, where equality of opportunity and of treatment are serious legal and philosophical considerations, teachers and administrators have a rationale based on this study for targeting additional time on a limited number of computers for individuals within a classroom.

D. Implications

The findings of this study indicate that extended use of computer-assisted instruction in the classroom by boys who are at-risk of failure can be accompanied by significant gains in mathematics achievement. Findings also indicate that 5th grade boys can achieve higher scores when exposed to extra computer time rather than to extra paper-and-pencil activities.

The mixed findings from this study raise some questions:

- What factors brought about the significant difference in achievement on the part of boys within the study but failed to produce significant differences among girls? Is it related to learning style? Does it reflect characteristics of girls who have been identified as at-risk?
- While boys using computers did not score significantly higher than girls using computers, boys in the computer group scored significantly higher than boys in the workbook group. Would this be a trend at other grade levels or in a study of a different length of time?
- While girls using computers achieved larger gains than those using workbooks or in the control group, differences were not significant. Would this finding occur with another sample or at another grade level? Is it related to true differences between the genders in cognitive abilities or is it a function of the at-risk profile?
- Rather than being positively skewed--having a concentration of high gain scores--gain scores

tended to approximate normal distributions. Is this pattern a function of the population, the time of year, the length of the study, or other variables? Likewise, the only gain score that deviated from a normal distribution was whole number operations. What factors contributed to a decrease in these math skills? Was this also a function of the timing (near summer vacation), carelessness, test over-load, or other variables?

- Although the focus of the study was on significant gains and not mastery, the question still arises: are significant gains adequate if a child still fails to master essential skills? Was there a high failure rate among these students corresponding to the failure to achieve mastery on the post-test ?

- While the literature is undecided about how much computer time-on-task is needed to make a statistically significant difference, the fact has been determined that more time-on-task usually produces better achievement. Would more time-on-task, whether computer or workbook, have produced greater gains?

E. Recommendations for Further Study

This study demonstrated significantly different differences in the mathematics achievement of at-risk boys using computers for greater amounts of time. The findings of this study and its implications provide the following recommendations for further research.

- Fifth grade was chosen for the sample drawn in this study because it is the last grade that deals primarily with arithmetic skills and is the highest grade that does not typically demonstrate significant differences in mathematics achievement between the genders. Replication of this study applied to other grades or age groups might extend the implications beyond the 5th grade.

- Most classroom studies are of a shorter duration than four months and usually show strong significant differences. Use of this study as a model for a year-long or a multi-year longitudinal investigation could show a trend in the rate of achievement gains found in this study or could show diminishing achievement of skill over the course of longer periods of time.

- This study could be used as a model for testing the effectiveness of other types of software (reading, composition, science, history) used with at-risk students and expand the validity of the study's findings to other subject matters. A corollary would be to investigate other types of computer-assisted instruction in mathematics (tutorial, higher order thinking, problem solving) to determine if the same significant differences would exist.

- The focus of this study was on significant gains, not mastery; 27.5% of students in the computer treatment demonstrated mastery on the post-test. Earlier the question was posed: are significant gains adequate if a child still fails to master essential skills? This study could be used as a model for further study with the addition of a component that tests the correlation of achievement on a post-test with mathematics class grades.

- The standard of thirty-additional minutes per week added to the district norm of 30 minutes was chosen for this study. Replication of this study with time as a variable might produce significant differences among girls in the treatment groups.

APPENDIX A
BASIS FOR THE SAMPLE

Basis for the Sample

By mandate of the state's education department, all students are assessed for their being at-risk of failure. Students are identified by central office personnel, who disseminate information among building personnel. Student performance is monitored during the course of the year; new names are included and others deleted should conditions so warrant. The initial list for the 1990-91 school year was compiled in late October.

In mid-October, letters approved by the district Research Committee (see Appendix E) were sent home to parents of all 5th grade students describing the study and giving parents an opportunity to withhold permission for their child to be included in a treatment group; ten letters were returned by parents of at-risk students denying permission to include their child in the study. At the same time, a list of all 5th grade students identified as "at-risk" was obtained from the district Director of Pupil Personnel Services; it was arranged by school but gender was not indicated. The name of any student denied parental permission was deleted from this list resulting in a total sampling frame of 245 at-risk students. An alphabetical list of all fifth grade students (1,409) in the district was obtained from the Regional X

Service Center. Since this list provided a randomized and systematic sampling frame, it was marked to indicate at-risk students and two new at-risk lists were then drawn up with names divided by gender.

Each of the at-risk gender lists was divided into sampling units of five; there were twenty-three clusters or sampling units of girls and twenty-seven clusters of boys. In each sampling unit, the first at-risk student (1) was assigned to the "standard time" control group; the third at-risk student (3) was assigned to the "extended time" experimental group; the fifth student (5) was assigned to the "extended time-on-task" experimental group, regardless of campus. Students assigned the number two (2) were engaged in a field test for the pre-test; students assigned the number four (4) field-tested the post-test. All students were coded by number. Due to family mobility, the original random sample of 150 students (81 boys and 69 girls) resulted in a final sample of 119 students (64 boys and 55 girls) who took both pre-test and post-test.

As a guide for obtaining an appropriate sample from a finite population, a formula was used from Sampling from a Finite Population, a paper presented by its author at a dissertation seminar at the University of North Texas (Spalding, working paper).

$$n = \frac{1}{\left(\frac{E}{ZS}\right)^2 + \left(\frac{1}{N}\right)}$$

n = sample size
 E = allowable error (2)
 Z = confidence level (set at 95%)
 S = estimated standard deviation (1/6 x 100
 questions = 16.7)
 N = size of finite population (245 on the final
 sampling frame)

$$n = \frac{1}{\left(\frac{2}{(1.96 \times 16.67)}\right)^2 + \left(\frac{1}{245}\right)}$$

$$n = \frac{1}{\left(\frac{2}{37.67}\right)^2 + \left(\frac{1}{245}\right)}$$

$$n = \frac{1}{(.061)^2 + \left(\frac{1}{245}\right)}$$

$$n = \frac{1}{(.0037) + \left(\frac{1}{245}\right)}$$

$$n = \frac{1}{(.0037) + (.0041)}$$

$$n = \frac{1}{.008}$$

n = 125 for a student sample

Predicting that some of the original sample would not be present for the post-test, 50 students were targeted for each cell of the model of Hypothesis I in the hopes that at least 30 would remain for the entire length of the study. After post-tests were scored, it was determined that approximately 80% of the original sample completed the study and well above the *n* targeted for the samples.

APPENDIX B

**Model for Teacher Supervision of
Students Engaged in C.A.I.**

Model for Teacher Supervision of Students Engaged in C.A.I.

1. In order for teachers to monitor appropriate computer time, students selected for experimental and control groups were identified for teachers. Students in the control or non-treatment group were not identified to teachers.
2. By state mandate all students have computer time each day; students in experimental groups had double that time (at least 10 minutes) of mathematics CAI per day.
3. Students logged on and off the computer using time sheets. Teachers were site monitors; the researcher made periodic site visits to monitor consistency with established procedures and student progress.
4. Students work independently at mathematics CAI.
5. Software listed in Appendix C was used; this software was correlated with state mandated Essential Elements (basic skills) and with district criterion-referenced tests (Appendices D and F).
6. District criterion-referenced tests had been validated for content validity.

APPENDIX C
CORRELATION AMONG TEXTBOOKS,
STATE OBJECTIVES, AND
COMPUTER SOFTWARE FOR
FIFTH GRADE MATHEMATICS

FIFTH GRADE MATHEMATICS
SEMESTER 1

CORRELATIONS AMONG TEXTS, OBJECTIVES, AND SOFTWARE

DISTRICT OBJECTIVES	HARCOURT (HBJ) CHAPTER	STATE OBJECTIVES GRADE 5	PROBLEM SOLVING (Addison Wesley)	COMPUTER-ASSISTED INSTRUCTION
A.1-A.3, A.6, A.7 C.11	1. Numeration	T1: Place Value	Sets 1. Guess & Check 2. Draw a Picture 3. Make a List	Essential Math- Number Concepts Speedway Math for drill and practice
B.1, B.2, B.10, B.11, C.4, C.7, C.8	2. Addition/ Subtraction	T3: Add and Subtract Decimals T6: 2-Step Word Problems: Whole numbers T8: 1-Step Word Problems: Decimal numbers	Sets 4. Make a Table 5. Work Backwards 6. Look for a Pattern	Essential Math: Add/Subtract

FIFTH GRADE MATHEMATICS
SEMESTER 1 (continued)

CORRELATIONS AMONG TEXTS, OBJECTIVES, AND SOFTWARE

DISTRICT OBJECTIVES	HARCOURT (HBJ) CHAPTER	STATE OBJECTIVES GRADE 5	PROBLEM SOLVING (Addison Wesley)	COMPUTER-ASSISTED INSTRUCTION
B.3, B.12, C.3, C.8.	3. Multiplying	T3. Add and Subtract Decimals	Sets 7. Use Logic	Essential Math: Multiplication
		T7: 1-Step Word Problems - multiplying and dividing whole numbers	8. Guess and Check	
C.11, C.12 F.4, F.5.	6. Graphing	T11: Perimeter or Area (Grids)	Sets 9. Draw a Picture 10. Make a List	None
B.4, B.5, b.15, C.1, C.8, C.9.	4. Dividing by 1-Digit Numbers	T4: Multiplying Whole Numbers T.7: 1-Step Word Problems: multiply and divide whole numbers	Sets 11. Make a Table 12. Work Backwards	Essential Math: Division

FIFTH GRADE MATHEMATICS
SEMESTER II
CORRELATIONS AMONG TEXTS, OBJECTIVES, AND SOFTWARE

DISTRICT OBJECTIVES	HARCOURT (HBJ) CHAPTER	STATE OBJECTIVES GRADE 5	PROBLEM SOLVING (Addison Wesley)	COMPUTER-ASSISTED INSTRUCTION
C.10, D.2-D.13, D.15-D18, E.9.	10. Measurement	T9: Measurement T10. Graphs	Sets 14. Use Logic	None
B.6 B.8, C.8.	5. Dividing by 2-Digit Numbers	T4: Multiplying Whole Numbers T7: 1-Step Word Problems multiplying and dividing whole numbers	Sets 15. Mixed Practice 16. Mixed Practice	Essential Math: Fractions
A.5, A.16, A.18-A.21 B.13, F.3, F.6, G.2.	7. Number Theory and Fractions	T2: Equivalent Fractions	Sets 17. Mixed Practice 18. Mixed Practice	Grogin's Fractions Adventures with Fractions

FIFTH GRADE MATHEMATICS
SEMESTER II (continued)

CORRELATIONS AMONG TEXTS, OBJECTIVES, AND SOFTWARE

DISTRICT OBJECTIVES	HARCOURT (HBJ) CHAPTER	STATE OBJECTIVES GRADE 5	PROBLEM SOLVING (Addison Wesley)	COMPUTER-ASSISTED INSTRUCTION
A.17, B.14.	8. Fractions: Addition and Subtraction	NA	Sets 19. Mixed Practice 20. Mixed Practice	Essential Math: Fractions
B.7-B.9 C.6	9. Fractions: Multiplication and Division	NA	Sets 21. Mixed Practice 22. Mixed Practice	Essential Math: Fractions
A.4, A.8-A.15, B.10, B.11, C.2, C.5, F.7.	11. Decimals: Addition and Sub- traction	T1: Place Value T5: Divide Whole Numbers T8: 1-Step Word Problems: Add and Subtract Decimals	Sets 23. Mixed Practice 24. Mixed Practice	Essential Math: Decimals

FIFTH GRADE MATHEMATICS
SEMESTER II (continued)

CORRELATIONS AMONG TEXTS, OBJECTIVES, AND SOFTWARE

DISTRICT OBJECTIVES	HARCOURT (HBJ) CHAPTER	STATE OBJECTIVES GRADE 5	PROBLEM SOLVING (Addison Wesley)	COMPUTER-ASSISTED INSTRUCTION
D.1, E.1-E.8	13. Geometry	T1: Place Value	Sets	None
		T5: Divide Whole Numbers	25. Mixed Practice	
		T8: 1-Step Word Problems: Add and Subtract Decimals	26. Mixed Practice	
B.12, C.9	12. Decimals: Multiplying and Dividing	NA	Sets	Essential Math: Decimals
			27. Mixed Practice	
			28. Mixed Practice	
D.14, F.1, F.2, G.1.	14. Ratio and Percent	T11: Perimeter or Area	Sets	Essential Math: Percent
			29. Mixed Practice	
			30. Mixed Practice	

APPENDIX D
PRE-TEST DOCUMENT

MATHEMATICS ASSESSMENT
ACTIVITY

- 1. Read the directions to each set of questions.**
- 2. For each question, select the best answer.**
- 3. Bubble in your choice on the answer sheet**
- 4. If you do not know the answer, select the choice that fits best.**
- 5. Please do *NOT* write in this booklet.**
- 6. Make sure that you do not make your marks *TOO* big on the answer sheets.**
- 7. Erase any unnecessary marks on your answer sheet.**
- 8. You may go back and check your answers.**

MATHEMATICS SKILLS ACTIVITY

Directions: Compare the numbers and choose the correct sign (symbol). Mark the correct answer on your answer sheet.

1. 1,357,747 _____ 1,357,874

- A) >
- B) <
- C) =

2. 717,264 _____ 717,164

- A) >
- B) <
- C) =

Directions: Mark the correct answer on your answer sheet.

3. Which group of numbers is in order from largest to smallest?

- A) 246; 642; 426
- B) 426; 246; 642
- C) 246; 426; 642
- D) 642; 426; 246

4. Which group of numbers is in order from smallest to largest?

- A) 763; 761; 762; 760
- B) 8,437; 8,439; 8,476; 8,467
- C) 1,763; 1,865; 1,871; 1,891
- D) 841; 869; 897; 879

Directions: Choose the number that fits the pattern.
Mark the correct answer on your answer sheet.

5. 8, 11, 14, 17, _____

- A) 21
- B) 20
- C) 19
- D) 18

6. 81, 77, 73, 69, _____

- A) 70
- B) 68
- C) 65
- D) 64

Directions: Mark the correct answer on your answer sheet.

7. Round 251, 678 to the nearest 100,000.

- A) 200,000
- B) 250,000
- C) 251,700
- D) 300,000

8. In the number 457,213, which digit is in the thousands place?

- A) 2
- B) 4
- C) 5
- D) 7

9. In the number 896,320, which digit is in the hundreds place?

- A) 3
- B) 6
- C) 8
- D) 9

Directions: Mark the correct answer on your answer sheet.

10. Solve the problem

$$\begin{array}{r} 1,646 \\ 3,281 \\ + 4,948 \\ \hline \end{array}$$

- A) 8,775
- B) 9,775
- C) 9,865
- D) 9,875

11. Solve the problem.

$$2,158 + 3,641 + 7,701 + 4,210 + 5,005 = \underline{\hspace{2cm}}$$

- A) 2,715
- B) 20,715
- C) 22,705
- D) 22,715

12. Solve the problem.

$$67,582 - 3,421 = \underline{\hspace{2cm}}$$

- A) 64,081
- B) 64,151
- C) 64,161
- D) 71,003

13. Solve the problem.

$$\begin{array}{r} 32,643 \\ - 16,475 \\ \hline \end{array}$$

- A) 16,168
- B) 26,168
- C) 48,118
- D) 49,118

Directions: Read each problem carefully. Mark the correct answer on your answer sheet.

14. Estimate the answer by rounding each number to the nearest 1,000.

$$\begin{array}{r} 3874 \\ 6396 \\ + 1598 \\ \hline \end{array}$$

- A) 13,000
 B) 12,000
 C) 11,000
 D) 10,000
15. Estimate the answer by rounding each number to the nearest 1,000.

$$7,834 - 2,157$$

- A) 10,000
 B) 8,000
 C) 7,000
 D) 6,000
16. Estimate the answer by rounding each number to the nearest 100.

$$\begin{array}{r} 615 \\ - 194 \\ \hline \end{array}$$

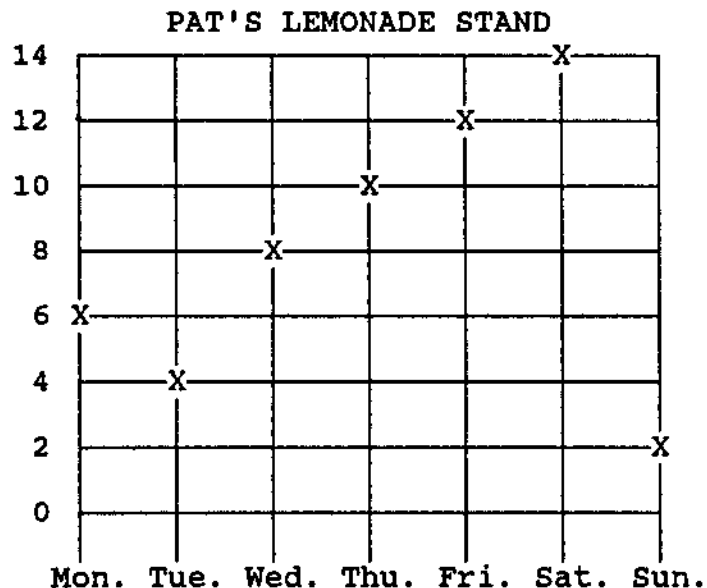
- A) 800
 B) 700
 C) 500
 D) 400
17. Jerry wants a bicycle that costs \$110.00. He saved the following amounts: January - \$35.50; February - \$39.00; March - \$26.80. How much more money must he save in April to have enough for his bicycle ?
- A) \$7.70 B) \$8.70
 C) \$19.30 D) \$101.30

Directions: Read each problem carefully.
Mark the correct answer on your answer sheet.

18. On a vacation trip the Smith family traveled 2,648 miles by car to a lake. On the return trip they took a shorter route and drove 2,023 miles. At the end of the trip, the car's odometer read 46,238 miles. What did the odometer read at the beginning of the trip?

- A) 4,671
- B) 41,567
- C) 43,590
- D) 50,909

Directions: Use the graph below to answer the question that follows. Mark the correct answer on your answer sheet.

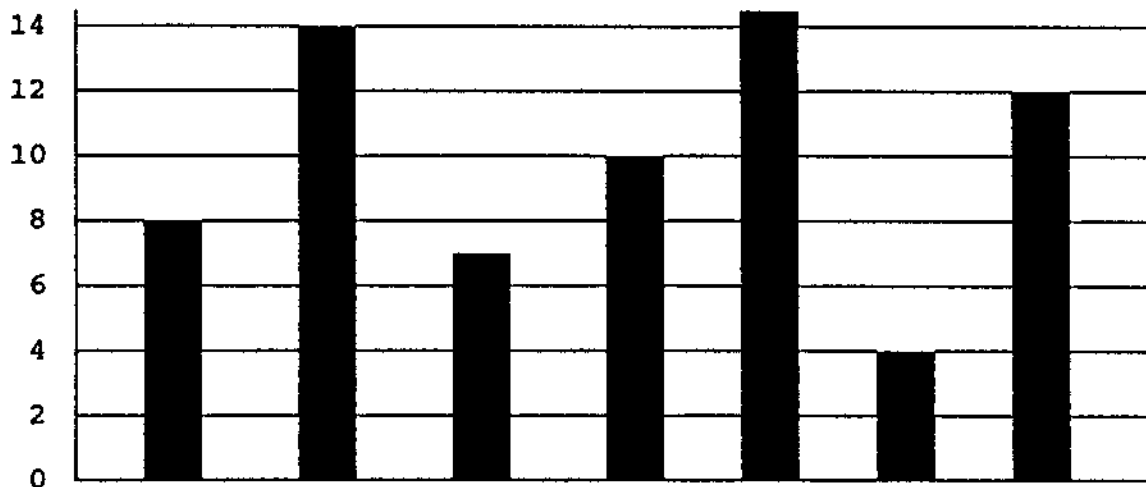


19. How many more glasses of lemonade did Pat sell on Thursday than on Wednesday ?

- A) 10
- B) 8
- C) 2
- D) 1

Directions: Use the graph below to answer the question that follows. Mark the correct answer on your answer sheet.

K I M ' S S T A M P S



Countries Canada China France India Italy Spain United States

20. How many more stamps does Kim have from China than from the United States ?

- A) 22
- B) 18
- C) 16
- D) 2

Directions: Mark the correct answer on your answer sheet.

21. Solve the problem.

$$\begin{array}{r} 862 \\ \times 395 \\ \hline \end{array}$$

- A) 1,257
- B) 14,644
- C) 339,690
- D) 340,490

Directions: Mark the correct answer on your answer sheet.

22. Solve the problem.

$$\begin{array}{r} 503 \\ \times 50 \\ \hline \end{array}$$

- A) 553
- B) 2,515
- C) 25,150
- D) 250,500

23. The height of four seventh grade students is 60, 62, 68, and 70 inches. What is their average height in inches ?

- A) 260 inches
- B) 65 inches
- C) 64 inches
- D) 62 inches

24. Solve the problem.

$$6 \overline{)13,267}$$

- A) 2,211 R2
- B) 2,211 R1
- C) 2,210 R1
- D) 2,011 R1

Directions: Estimate the quotient by rounding the dividend to the nearest 100 and the divisor to the nearest 10. Mark the correct answer on your answer sheet.

25. Estimate.

$$32 \overline{)904}$$

- A) 3
- B) 30
- C) 33
- D) 330

Directions: Estimate the product by rounding the first factor to the nearest 10 and the second factor to the nearest 100. Mark the correct answer on your answer sheet.

26. Estimate. 56×495

- A) 560
- B) 3,000
- C) 5,000
- D) 30,000

Directions: Read each problem carefully.
Mark the correct answer on your answer sheet.

27. The science library has 18 shelves of books. There are 108 books on each shelf. How many books are there in all?

- A) 6
- B) 126
- C) 1,884
- D) 1,944

28. There are 31,582 people living in Southville and 15,248 people living in Toyville. How many more people live in Southville than live in Toyville ?

- A) 16,334
- B) 16,345
- C) 26,334
- D) 46,830

29. Dora traveled 20 miles in four hours. What was her average speed in miles per hour ?

- A) 4 mph
- B) 5 mph
- C) 16 mph
- D) 24 mph

30. Jerry's team has won 3 out of 9 games. If his team continues to win at this rate, how many games will his team win in 36 games ?

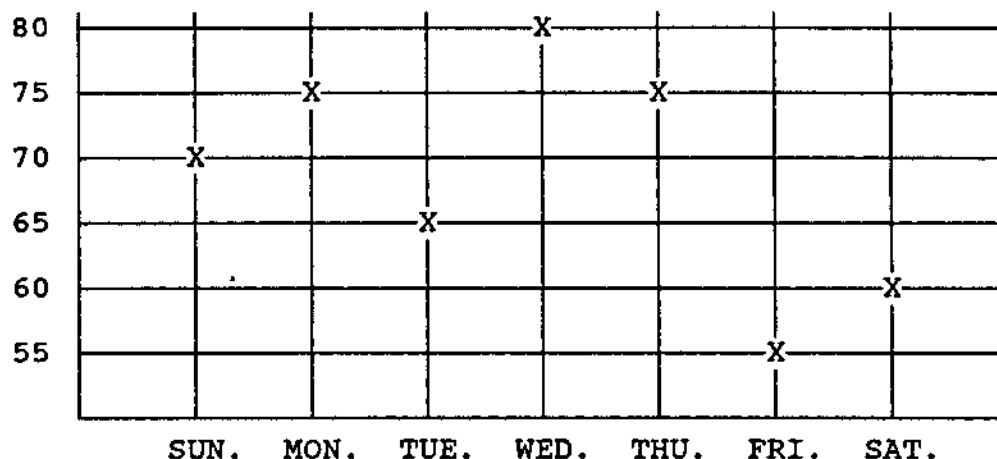
- A) 12
- B) 24
- C) 27
- D) 33

31. 2 Zachs weigh the same as 3 Zotos. If a rock weighs 12 Zachs, what is its weight in Zotos ?

- A) 5
- B) 8
- C) 18
- D) 36

Directions: Use the graph below to answer the question that follows. Mark the correct answer on your answer sheet.

DAILY NOON TEMPERATURES FOR ONE WEEK

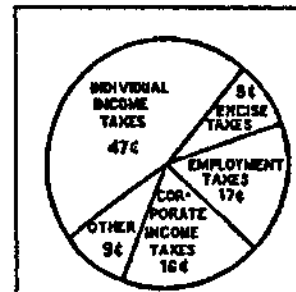


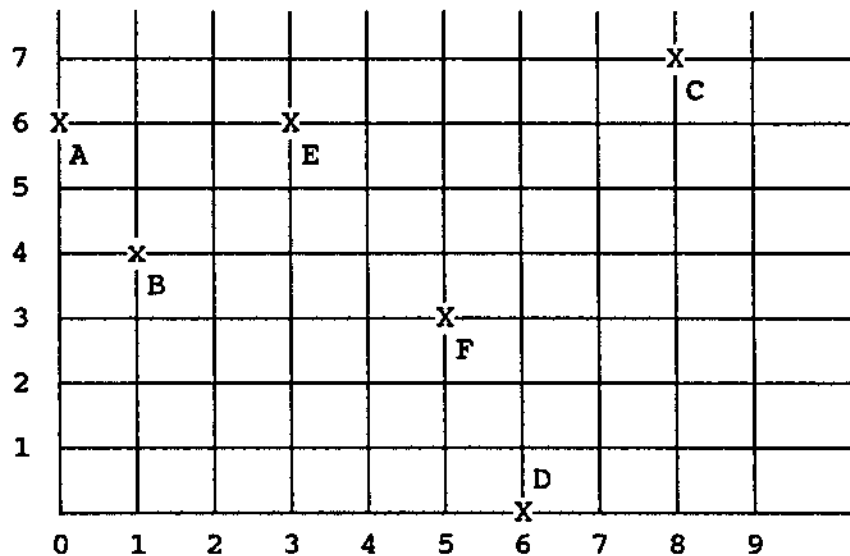
32. Which day was colder than Saturday ?

- A) Sunday
- B) Monday
- C) Tuesday
- D) Friday

33. Where does the largest part of the Federal Government Dollar come from ?

- A) Defense Department
- B) Employment taxes
- C) Corporation income taxes
- D) Individual income taxes





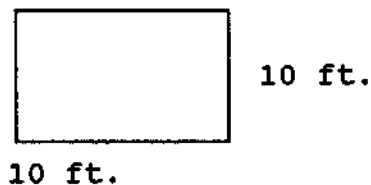
34. Which is the ordered pair for E ?

- A) (3,3)
- B) (3,6)
- C) (6;3)
- D) (0,6)

Directions: Read each problem carefully. Mark the correct answer on your answer sheet.

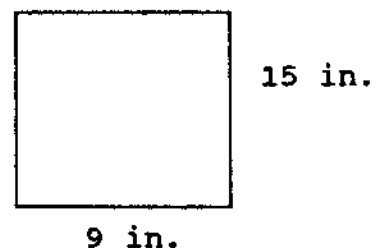
35. A wall is 10 feet tall and 10 feet wide. What is the perimeter of the wall ?

- A) 20 ft
- B) 40 ft.
- C) 40 sq. ft.
- D) 100 sq. ft.



36. A tray is 15 inches long and 9 inches wide. What is the area of the tray ?

- A) 24 in.
- B) 48
- C) 48 sq. in.
- D) 135 sq. in.



Directions: Read each problem carefully.
Mark the correct answer on your answer sheet.

37. The freezing point on the Fahrenheit thermometer is ____° F.

- A) 0
- B) 30
- C) 32
- D) 35

38. The freezing point on the Celsius thermometer is ____° C.

- A) 0
- B) 30
- C) 32
- D) 35

39. The weight of a baby bird can be measured in _____ .

- A) kilometers
- B) meters
- C) liters
- D) grams

40. A trip across the United States can be measured in _____ .

- A) liters
- B) grams
- C) kilometers
- D) kilograms

41. The liquid volume of a can of cola can be measured in _____ .

- A) feet
- B) hours
- C) yards
- D) pints

42. 3 pounds = _____ ounces

- A) 48
- B) 36
- C) 30
- D) 6

Directions: Read each problem carefully.
Mark the correct answer on your answer sheet.

43. 64 ounces = _____ pounds

- A) 1,024
- B) 32
- C) 6.4
- D) 4

44. 4 kilometers = _____ meters

- A) 4
- B) 40
- C) 400
- D) 4,000

45. 19.4 meters = _____ centimeters

- A) 0.194
- B) 1.94
- C) 194
- D) 1,940

46. 48 inches = _____ feet

- A) 1.3
- B) 4.0
- C) 4.8
- D) 576

47. 61.3 centimeters = _____ millimeters

- A) 0.0613
- B) 6.13
- C) 613
- D) 6,130

48. 5 kilograms = _____ grams

- A) 5
- B) 50
- C) 500
- D) 5,000

49. Find the area of the rectangle.

- A) 36 units
- B) 6 sq. units
- C) 6 units
- D) 5 sq. units



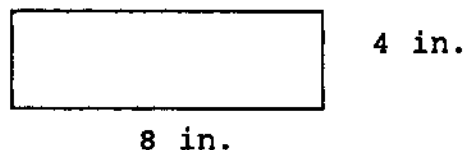
50. Find the perimeter of the rectangle.

- A) 16 units
- B) 12 sq. units
- C) 8 square units
- D) 8 units

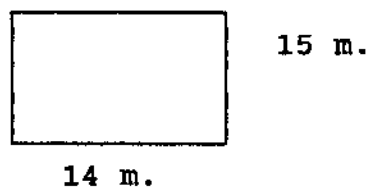


Directions: Find the area of each rectangle below by using the formula $\text{Area} = \text{length} \times \text{width}$. Mark the correct answer on your answer sheet.

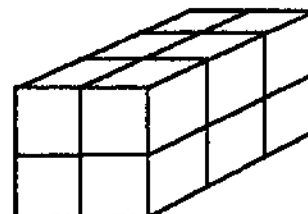
51. A) 12 sq. in.
 B) 24 in.
 C) 32 in.
 D) 32 sq. in.



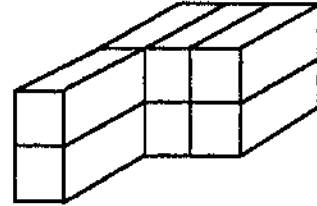
52. A) 29 sq. m.
 B) 58 m.
 C) 210 sq. m.
 D) 1,470 sq. m.



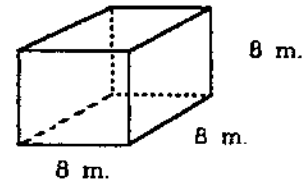
53. A) 16 cubic centimeters
 B) 12 cubic centimeters
 C) 10 cubic centimeters
 D) 6 cubic centimeters



54. A) 12 cubic centimeters
 B) 10 cubic centimeters
 C) 8 cubic centimeters
 D) 6 cubic centimeters



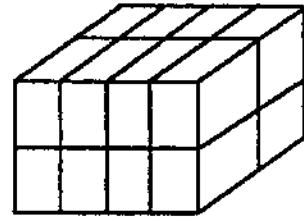
55. A) 48 square meters
 B) 64 cubic meters
 C) 512 cubic meters
 D) 514 cubic meters



Directions: Find the surface area of the rectangular prism below. Mark the correct answer on your answer sheet.

56. Find the surface area of the rectangle.

- A) 40 sq. units
 B) 20 sq. units
 C) 16 sq. units
 D) 12 sq. units



Directions: Change the number in exponent form to a whole number. Mark the correct answer on your answer sheet.

57. $3^2 =$ _____

- A) 18
 B) 9
 C) 6
 D) 5

58. $5^1 =$ _____

- A) 51
 B) 6
 C) 5
 D) 1

Directions: Compare the fractions and choose the correct sign (symbol). Mark the correct answer on your answer sheet.

56.

$$\frac{7}{8} - \frac{6}{8}$$

- A) >
 B) <
 C) =

60.

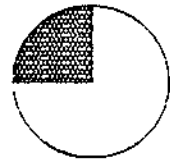
$$\frac{4}{5} - \frac{5}{5}$$

- A) >
 B) <
 C) =

Directions: Mark the correct answer on your answer sheet.

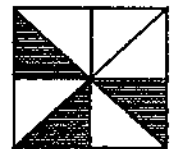
61. What portion of the circle is shaded.

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



62. What portion of the square is shaded.

- A) $\frac{8}{11}$ B) $\frac{5}{3}$ C) $\frac{3}{5}$ D) $\frac{3}{8}$



Directions: Choose the fraction that shows what part of the total object is shaded. Mark the correct answer on your answer sheet.

63.



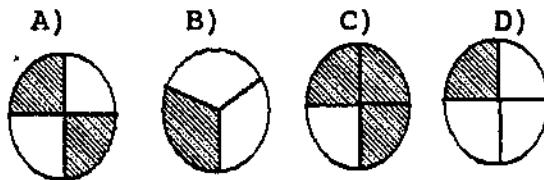
A) $\frac{2}{3}$

B) $\frac{1}{4}$

C) $\frac{1}{3}$

D) $\frac{1}{2}$

64. Which picture shows $\frac{1}{2}$ of the circle shaded ?



Directions: Mark the correct answer on your answer sheet.

65. Reduce $\frac{48}{100}$ to lowest terms

A) $\frac{11}{25}$

B) $\frac{25}{12}$

C) $\frac{100}{48}$

D) $\frac{12}{25}$

66. Reduce $\frac{4}{12}$ to lowest terms.

A) $\frac{1}{3}$

B) $\frac{1}{4}$

C) $\frac{2}{3}$

D) $\frac{12}{4}$

Directions: Mark the correct answer on your answer sheet.

67. Which mixed number is equal to $\frac{7}{4}$?

- A) $1\frac{4}{7}$ B) $1\frac{3}{7}$ C) $1\frac{3}{4}$ D) $2\frac{1}{4}$

68. Which improper fraction is equal to $5\frac{2}{7}$?

- A) $\frac{12}{7}$ B) $\frac{10}{7}$ C) $\frac{7}{37}$ D) $\frac{37}{7}$

69. Find the least common multiple (LCM) of 4 and 6.

- A) 2
B) 4
C) 12
D) 24

70. Find the least common multiple (LCM) of 3 and 4.

- A) 0
B) 3
C) 7
D) 12

Directions: Use the graph below to answer the question that follows. Mark the correct answer on your answer sheet.

	hats	flags	stickers
Janet	14	5	8
Mike	10	7	9
Sarah	3	2	12
Jim	5	10	11
TOTAL	32	24	40

71. How many more hats did Mike sell than Jim ?

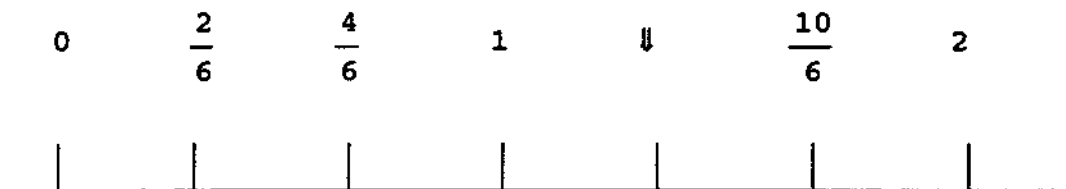
- A) 8
- B) 7
- C) 5
- D) 3

72. Who sold less stickers than Mike ?

- A) Janet
- B) Mike
- C) Sarah
- D) Jim

Directions: Identify the fraction shown by the point.
Mark the correct answer on your answer sheet.

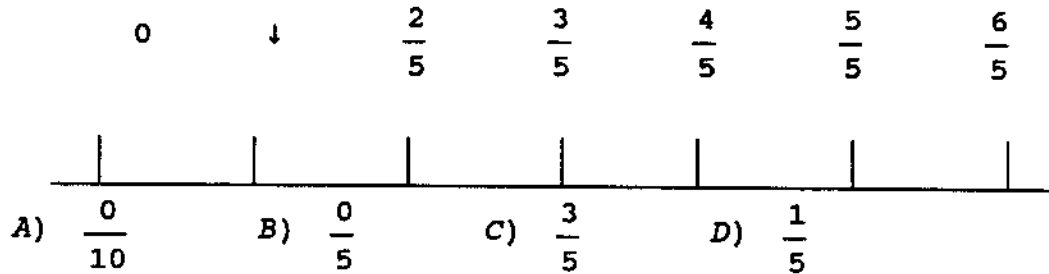
73.



- A) $\frac{1}{6}$
- B) $\frac{8}{6}$
- C) $\frac{6}{8}$
- D) $\frac{2}{6}$

Directions: Identify the fraction shown by the point.
Mark the correct answer on your answer sheet.

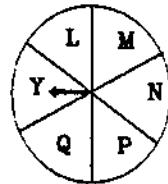
74.



Directions: Mark the correct answer on your answer sheet.

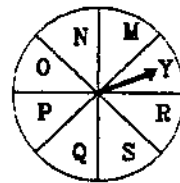
75. What is the probability of the spinner stopping at Y?

- A) $\frac{5}{6}$ B) $\frac{1}{6}$ C) $\frac{1}{5}$ D) $\frac{1}{7}$



76. What is the probability of the spinner stopping at Y?

- A) $\frac{7}{8}$ B) $\frac{1}{7}$ C) $\frac{1}{9}$ D) $\frac{1}{8}$



Directions: Compare the numbers and choose the correct sign (symbol). Mark the correct answer on your answer sheet.

77. 4.3 _____ 4.23

- A) >
B) <
C) =

Directions: Compare the numbers and choose the correct sign (symbol). Mark the correct answer on your answer sheet.

78. 0.08 _____ 0.8

- A) >
- B) <
- C) =

Directions: Mark the correct answer on your answer sheet.

79. What does the digit 7 stand for in 39.017 ?

- A) 7 thousandths
- B) 7 hundredths
- C) 7 tenths
- D) 7 ones

80. What does the digit 2 stand for in 86.235 ?

- A) 2 thousandths
- B) 2 hundredths
- C) 2 tenths
- D) 2 ones

81. What is another name for seventeen and six tenths ?

- A) 1.67
- B) 1.76
- C) 17.6
- D) 176

82. What is another name for six hundred fifty-nine thousandths ?

- A) 0.59
- B) 0.659
- C) 6.065
- D) 6.590

Directions: Choose the decimal numeral that is the same as the fraction. Mark the correct answer on your answer sheet.

83. What is the equivalent decimal for $\frac{17}{100}$?

- A) 0.017
- B) 0.17
- C) 17.01
- D) 17.100

84. What is the equivalent decimal for $\frac{34}{100}$?

- A) 0.034
- B) 0.134
- C) 0.34
- D) 0.66

85. What is the equivalent decimal for $\frac{6}{1000}$

- A) 0.006
- B) 0.06
- C) 0.6
- D) 6600

Directions: Mark the correct answer on your answer sheet.

86. Find the least common denominator for:

- $\frac{3}{5}$, $\frac{1}{3}$
- A) 15
 - B) 5
 - C) 3
 - D) 1

86. Find the least common denominator for:

- $\frac{3}{4}$, $\frac{1}{6}$
- A) 24
 - B) 12
 - C) 6
 - D) 4

88. Solve the problem and reduce to lowest terms.

$$\frac{4}{7} \times \frac{2}{3}$$

- A) $\frac{8}{21}$ B) $\frac{6}{21}$ C) $\frac{6}{10}$ D) $\frac{8}{10}$

89. Solve the problem and reduce to lowest terms.

$$\frac{3}{4} \times \frac{1}{3}$$

- A) $\frac{4}{12}$ B) $\frac{4}{7}$ C) $\frac{1}{4}$ D) $\frac{3}{7}$

90. Solve the problem: $58.69 + 70.941 =$

- A) 768.10
B) 128.641
C) 129.631
D) 139.531

91. Solve the problem:

$$\begin{array}{r} 6.24 \\ + 0.382 \\ \hline \end{array}$$

- A) 6.522
B) 6.523
C) 6.562
D) 6.622

92. Solve the problem: $31.65 - 5.4$

- A) 2.625
B) 26.25
C) 34.25
D) 36.25

93. Solve the problem:

$$\begin{array}{r} 4.12 \\ - 0.98 \\ \hline \end{array}$$

- A) 3.14
 B) 4.14
 C) 4.86
 D) 31.4

94. Solve the problem.

$$\begin{array}{r} \frac{11}{16} \\ + \frac{4}{16} \\ \hline \end{array}$$

- A) $\frac{6}{16}$ B) $\frac{7}{16}$ C) $\frac{13}{16}$ D) $\frac{15}{16}$

95. Solve the problem.

$$\begin{array}{r} \frac{1}{4} \\ + \frac{1}{6} \\ \hline \end{array}$$

- A) $\frac{1}{2}$ B) $\frac{2}{5}$ C) $\frac{2}{10}$ D) $\frac{5}{12}$

96. Solve the problem.

$$\begin{array}{r} \frac{5}{9} \\ - \frac{3}{9} \\ \hline \end{array}$$

- A) $\frac{2}{9}$ B) $\frac{8}{9}$ C) $\frac{8}{18}$ C) $\frac{14}{18}$

Directions: Estimate the answer by rounding numbers to the nearest hundredth. Mark your answer on your answer sheet.

97.
$$\begin{array}{r} 16.283 \\ + 8.369 \\ \hline \end{array}$$

A)
$$\begin{array}{r} 16.28 \\ + 8.37 \\ \hline 24.65 \end{array}$$

B)
$$\begin{array}{r} 16.3 \\ + 8.2 \\ \hline 24.5 \end{array}$$

C)
$$\begin{array}{r} 16.29 \\ + 8.30 \\ \hline 24.59 \end{array}$$

D)
$$\begin{array}{r} 16.29 \\ + 8.35 \\ \hline 24.64 \end{array}$$

98.
$$\begin{array}{r} 43.642 \\ + 21.829 \\ \hline \end{array}$$

A)
$$\begin{array}{r} 43.62 \\ - 21.82 \\ \hline 21.80 \end{array}$$

B)
$$\begin{array}{r} 43.60 \\ - 21.90 \\ \hline 21.70 \end{array}$$

C)
$$\begin{array}{r} 43.65 \\ - 21.83 \\ \hline 21.82 \end{array}$$

D)
$$\begin{array}{r} 43.64 \\ - 21.83 \\ \hline 21.81 \end{array}$$

99. Jenny bought some ice cream that cost \$0.79. How much change should Jenny receive if she gives the clerk \$5.00 ?

- A) \$0.21
- B) \$4.21
- C) \$4.79
- D) \$5.79

100. Bob wants to buy a bird feeder for \$3.75, a bird house for \$1.49, and a bird bath for \$5.47. What will be the total cost if he buys all three?

- A) \$9.62
- B) \$9.71
- C) \$10.62
- D) \$10.71

APPENDIX E
LETTERS OF CONSENT

October 15, 1991

Dear Parents:

I know that you are aware of our district's commitment to providing the best education possible for our children. One factor in that educational process is preparing our children for the challenges and technology of the 21st Century; computers impact all of our lives and are an important part of that technology.

I will be conducting research with 5th graders designed to study how the computer helps them learn. This study will not interfere in any way with your child's regular class schedule. My purpose is to see how effective some classroom strategies are that we currently use in Texas and how we might better serve our children's needs. This study consists of randomly selecting students whose progress in mathematics will be charted for purposes of this study only; each child selected will be coded and his or her identity will remain anonymous. Results will be reported for groups only; at the end of the year, I will need to access math achievement. At all times, all children will maintain access to the computers in the classroom and in the computer labs as regularly scheduled.

Your decision whether or not to let your child participate will in no way affect you child's standing in his or her class. At the conclusion of the study, a summary of result will be available for any interested parents or school personnel. This project has been approved by the Carrollton-Farmers Branch I. S. D. and by the University of North Texas Committee for the Protection of Human Subjects (817-267-3731, x3946).

We appreciate your cooperation in identifying strategies for students to learn more and to succeed at school. If you have any questions, please call me at the schools listed below or you may direct questions to the project advisor, Dr. Frank Halstead, University of North Texas (817-267-3731, x2843).

Sincerely yours,

Christopher A. Salerno,
Administrative Assistant
Davis Elementary School (323-6610)
Blanton Elementary School (323-6600)

Please indicate if you **do not** want your child to take part in this project and then return this letter to your child's teacher before October 22, 1990.

I DO NOT GRANT PERMISSION FOR MY CHILD _____

_____ TO PARTICIPATE.

Parent/Guardian's signature

Estimados padres de familia,

Como Ud. ya sabe, las computadores son una parte importante del futuro y en las escuelas estamos preparando a sus hijos para que participen en ese futuro. Yo soy un asistent director en las escuelas y estoy investigando el efecto del entrenamiento sobre computadores en el apendizaje de la matimática de nuestros estudiantes. Con esta investigación procuraremos mejorar nuestra enseñanza de la computadora en las escuelas.

Estamos pidiéndole que su hijo o hija participe en esta investigación. No le cambiará nada su horario o estudios.

Si tiene alguna pregunta, llame a John G. a 323-6644 por una explicación en español.

Atentamente,

Christopher A. Salerno,
Asistente Director
Davis Elementary School
Blanton Elementary School

Por favor, si no quiere que participe en este proyecto, devuela esta hoja.

(Si está bien que participe, Ud. no tiene que devolver nada.

NO QUIERER QUE MI NIÑO O NIÑA _____

_____ PARTICIPE.

Firma de padre de familia

APPENDIX F
POST-TEST DOCUMENT:
SAMPLE QUESTIONS

MATHEMATICS ASSESSMENT
FINAL ACTIVITY

- 1. Please do NOT write in this booklet.**
- 2. Read the directions to each set of questions.**
- 3. For each question, select the best answer.**
- 4. Bubble in your choice on the answer sheet:**

1 - 50 PART 1/SIDE 1

100 - 150 PART 2/SIDE 2

- 5. If you do not know the answer, select the choice you think might BEST fit.**
- 6. Do not make your marks TOO big on the answer sheets.**
- 7. You may go back and check your answers.**

MATHEMATICS SKILLS ACTIVITY

Directions: Compare the numbers and choose the correct sign (symbol). Mark the correct answer on your answer sheet.

1. 9,876,432 _____ 9,876,430

- A) >
- B) <
- C) =

2. 6,543,021 _____ 6,584,158

- A) >
- B) <
- C) =

Directions: Mark the correct answer on your answer sheet.

3. Which group of numbers is in order from largest to smallest?

- A) 8,431; 632,156; 98,605; 4,023
- B) 632,156; 98,605; 8,431; 4,023
- C) 4,023; 8,431; 98,605; 632,156
- D) 4,023; 632,156; 8,431; 98,605

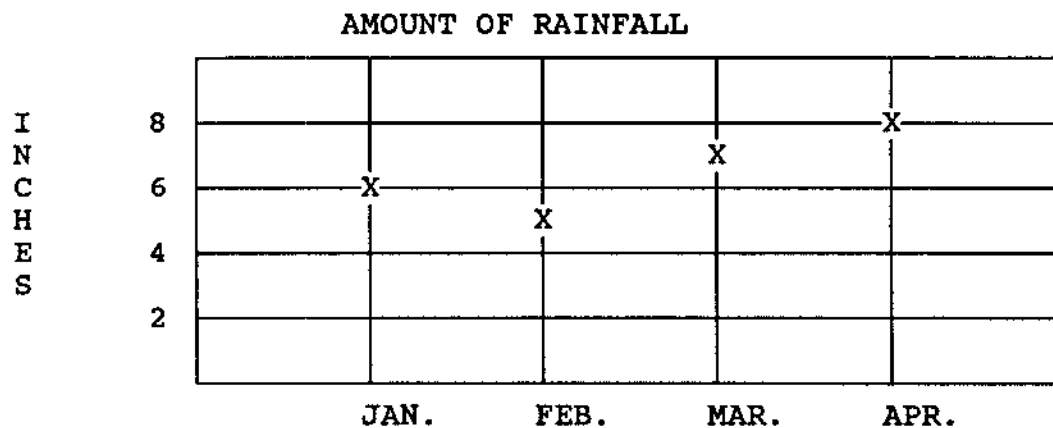
4. Which group of numbers is in order from smallest to largest?

- A) 103,211; 12,015; 104,084; 19,461
- B) 103,211; 104,084; 12,015; 19,461
- C) 104,084; 103,211; 19,461; 12,015
- D) 12,015; 19,461; 103,211; 104,084

Directions: Read the problem below carefully.
Mark the correct answer on your answer sheet.

22. Bill bought 12 pencils at 4 cents each and 6 more pencils at 10 cents each. What was the average cost of each pencil ?
- A) 5 cents
 - B) 6 cents
 - C) 18 cents
 - D) 48 cents

Directions: Use the graph below to answer the question that follows. Mark the correct answer on your answer sheet.



23. Which month had 8 inches of rain ?
- A) Jan.
 - B) Feb.
 - C) Mar.
 - D) Apr.

Directions: Read each problem carefully.
Mark the correct answer on your answer sheet.

45. The weight of your pencil can be measured in _____.

- A) ounces
- B) gallons
- C) inches
- D) pints

46. 7 pounds = _____ ounces

- A) 112
- B) 84
- C) 70
- D) 14

47. 80 ounces = _____ pounds

- A) 1,280
- B) 40
- C) 5
- D) 4

48. 6 yards = _____ feet

- A) 2
- B) 18
- C) 72
- D) 216

49. 87 milliliters = _____ centiliters

- A) 7.8
- B) 8.7
- C) 780
- D) 870

50. 5 kilograms = _____ grams

- A) 5
- B) 50
- C) 500
- D) 5,000

P L E A S E S T O P !

TURN OVER YOUR BLUE ANSWER SHEET AND LOOK

FOR ANSWER BLANK NUMBER 101.

NOW TURN TO THE NEXT PAGE IN THIS BOOKLET.

THE NEXT QUESTION IS QUESTION NUMBER 101.

Directions: Read each problem carefully.
Mark the correct answer on your answer sheet.

101. 4.8 liters = _____ milliliters

- A) 48
- B) 48.80
- C) 480
- D) 4,800

102. Find the perimeter of the square.

- A) 12 units
- B) 9 sq. units
- C) 6 sq. units
- D) 6 units



103. Find the area of the square.

- A) 16 sq. units
- B) 12 units
- C) 8 sq. units
- D) 8 units



Directions: Find the area of the rectangles below. Use the formula $\text{Area} = \text{length} \times \text{width}$. Mark the correct answer on the answer sheet.

104.
 - A) 28 ft.
 - B) 56 ft.
 - C) 187 sq. ft.
 - D) 191 sq. ft.



11 ft.

17 ft.

105.
 - A) 20 sq. cm
 - B) 22 cm
 - C) 40 cm
 - D) 84 sq. cm



14 cm

6 cm

Directions: Mark the correct answer on your answer sheet.

129. Solve the problem.

$$\begin{array}{r} \frac{5}{9} \\ - \frac{3}{9} \\ \hline \end{array}$$

- A) $\frac{2}{9}$ B) $\frac{8}{9}$ C) $\frac{8}{18}$ D) $\frac{14}{18}$

130. Solve the problem and reduce to lowest terms.

$$\frac{6}{7} \times \frac{2}{3}$$

- A) $\frac{8}{21}$ B) $\frac{4}{7}$ C) $\frac{8}{10}$ D) $\frac{12}{10}$

131. Solve the problem and reduce to lowest terms.

$$\frac{3}{5} \times \frac{5}{7}$$

- A) $\frac{4}{7}$ B) $\frac{8}{35}$ C) $\frac{3}{7}$ D) $\frac{8}{12}$

132. Find the least common multiple (LCM) of 3 and 7.

- A) 3
B) 10
C) 21
D) 63

Directions: Mark the correct answer on your answer sheet.

145. Solve the problem: $0.76 + 0.899 =$

- A) 0.975
- B) 1.559
- C) 1.650
- D) 1.659

146. Solve the problem:

- A) 1.029
- B) 1.129
- C) 1.228
- D) 1.229

$$\begin{array}{r} 0.437 \\ + 0.692 \\ \hline \end{array}$$

147. Solve the problem: $0.780 - 0.143$

- A) 0.537
- B) 0.547
- C) 0.637
- D) 0.643

148. Solve the problem:

- A) 1.12
- B) 1.28
- C) 2.12
- D) 2.88

$$\begin{array}{r} 2.1 \\ - 0.98 \\ \hline \end{array}$$

149. Solve the problem:

- A) 0.748
- B) 7.468
- C) 7.488
- D) 8.560

$$\begin{array}{r} 9.36 \\ \times 0.8 \\ \hline \end{array}$$

APPENDIX G
SAMPLES FROM THE STUDENT WORKBOOK
ELECTRIC MATH

Please divide.

1. $8 \div 4 =$

2. $\frac{20}{5} =$

3. $8 \overline{)48}$

4. $81 \div 9 =$

5. $\frac{32}{8} =$

6. $\frac{25}{5} =$

7. $16 \div 8 =$

8. $5 \overline{)15}$

9. $\frac{56}{8} =$

10. $45 \div 9 =$

11. $\frac{27}{3} =$

12. $\frac{10}{2} =$

13. $12 \div 3 =$

14. $\frac{54}{6} =$

15. $9 \overline{)36}$








16. $72 \div 8 =$

Katherine Hepburn has won the most Oscars for starring roles in movies. How many has she won? (See problem 8.)



HORIZONTAL AND VERTICAL DIVISION
WITH SINGLE DIGIT DIVISOR

→

<p>Please divide.</p> 	<p>1. $3\overline{)93}$</p>	<p>2. $4\overline{)48}$</p>	
<p>3. $2\overline{)68}$</p>	<p>4. $5\overline{)255}$</p>		<p>5. $4\overline{)328}$</p>
	<p>6. $6\overline{)306}$</p>	<p>7. $7\overline{)357}$</p>	
<p>8. $9\overline{)729}$</p>			<p>9. $8\overline{)88}$</p>

DIVISION WITH 1-DIGIT DIVISOR

1. $36 \overline{)864}$

2. $19 \overline{)703}$

3. $27 \overline{)972}$

4. $34 \overline{)71}$

5. $32 \overline{)1312}$

6. $65 \overline{)4680}$

7. $81 \overline{)2997}$

8. $92 \overline{)2484}$

9. $43 \overline{)2709}$

POOP

Please divide.

ZAP

RIZZLE

GAG


DIVISION WITH 2-DIGIT DIVISOR

Please divide.

1. $256 \div 16 =$

2. $7,488 \div 234 =$

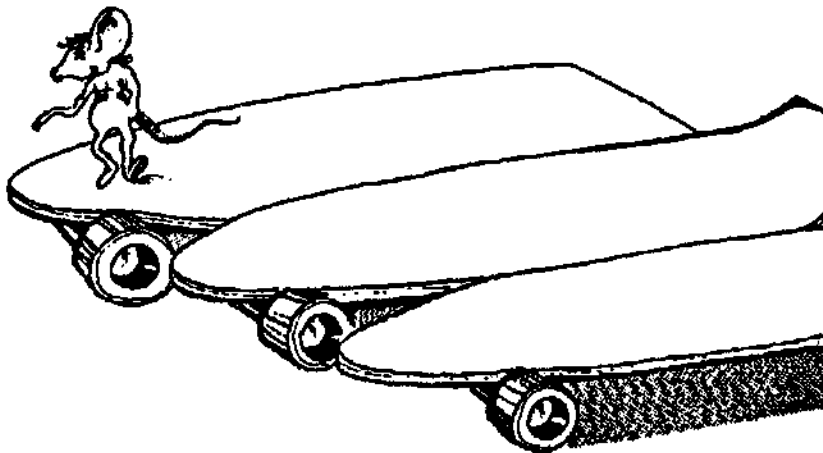
3. $583,746 \div 291 =$



4. $2,892 \div 85 =$

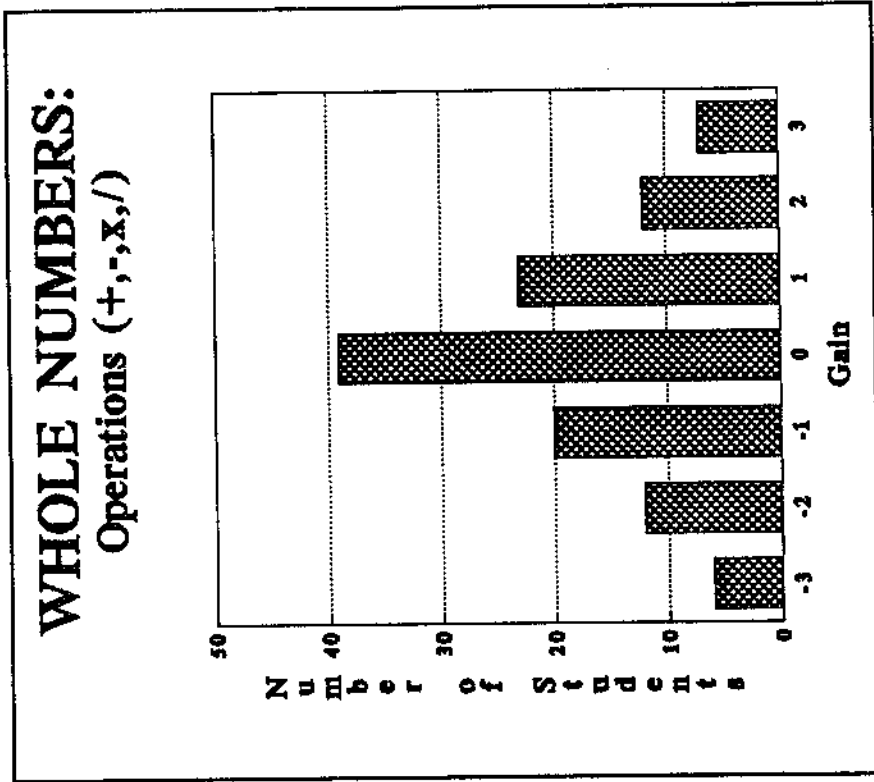
**HORIZONTAL DIVISION WITH
2- AND 3-DIGIT DIVISORS**

1. Divide 3,252 by 26.
2. Find the quotient if the divisor is 14 and the dividend is 6,384.
3. 39,072 divided by 44 is what number?
4. Divide 5,246 by 19.

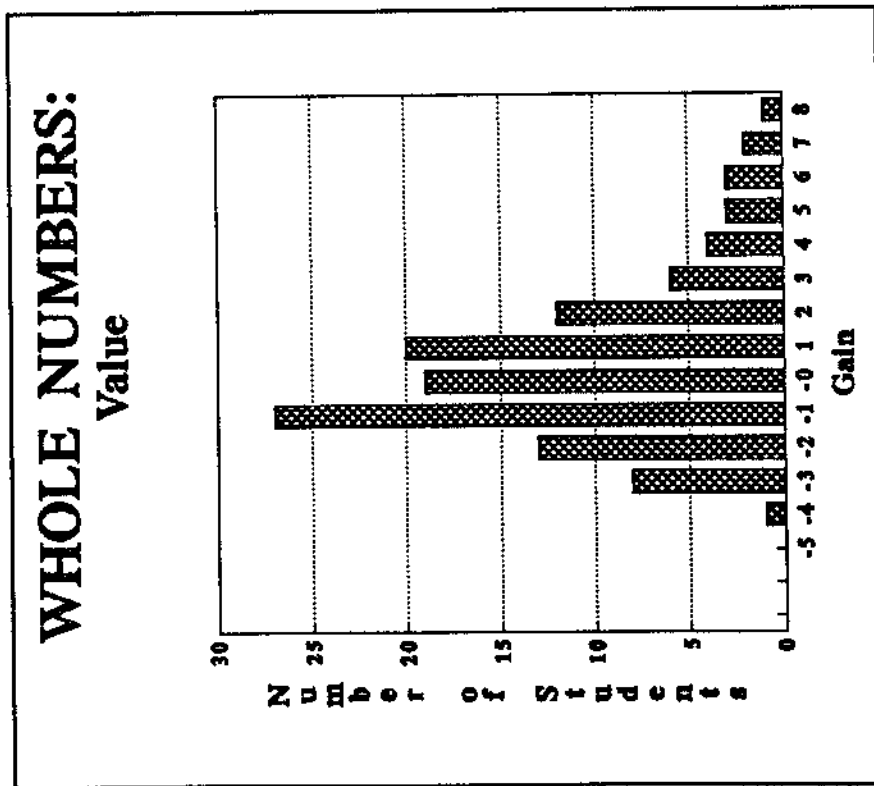


***DIVISION WORD PROBLEMS
WITH 2-DIGIT DIVISOR***

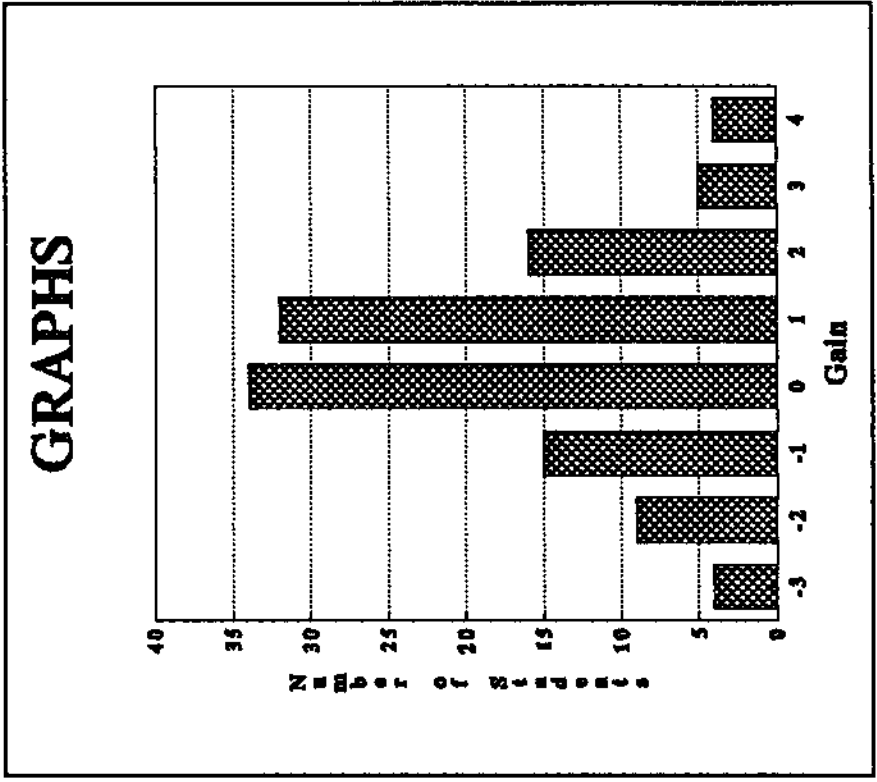
APPENDIX H
SUB-SKILL GRAPHS



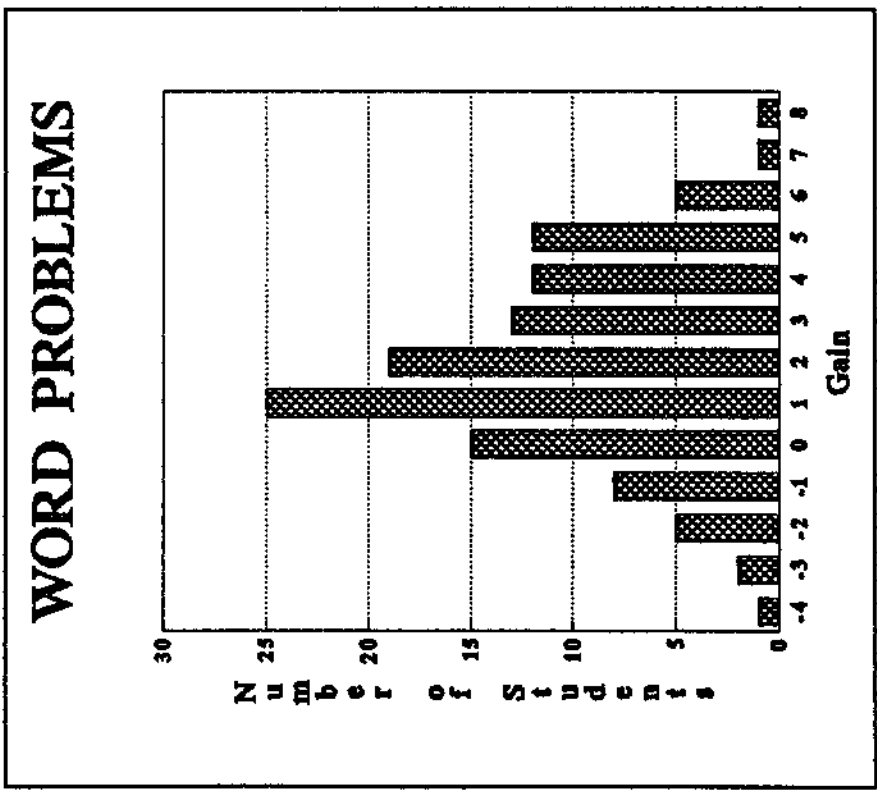
GRAPH 2 - TOTAL GAINS



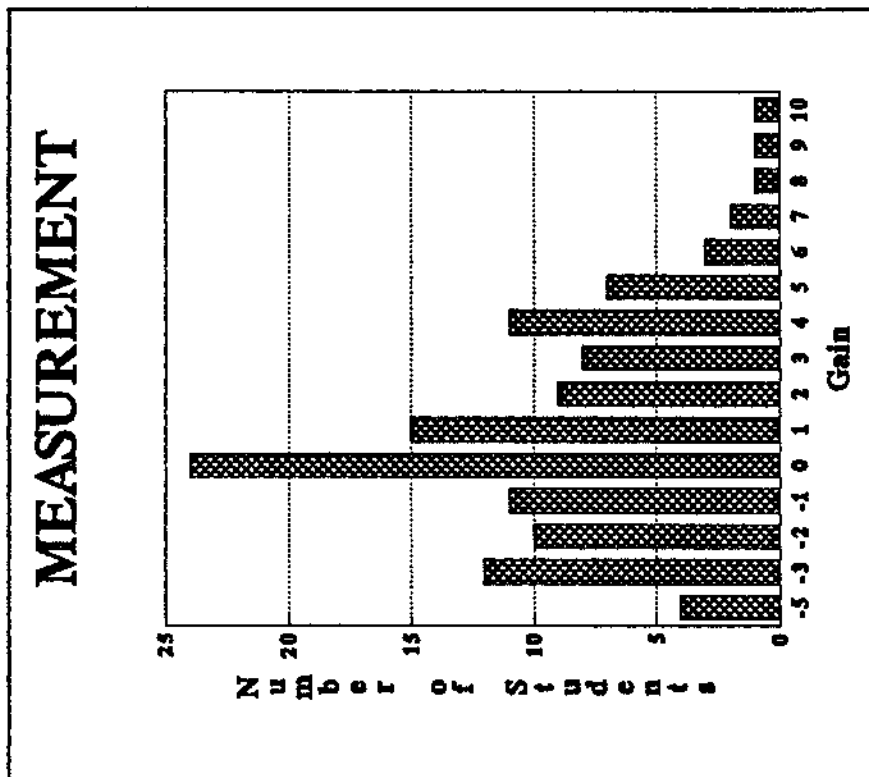
GRAPH 1 - TOTAL GAINS



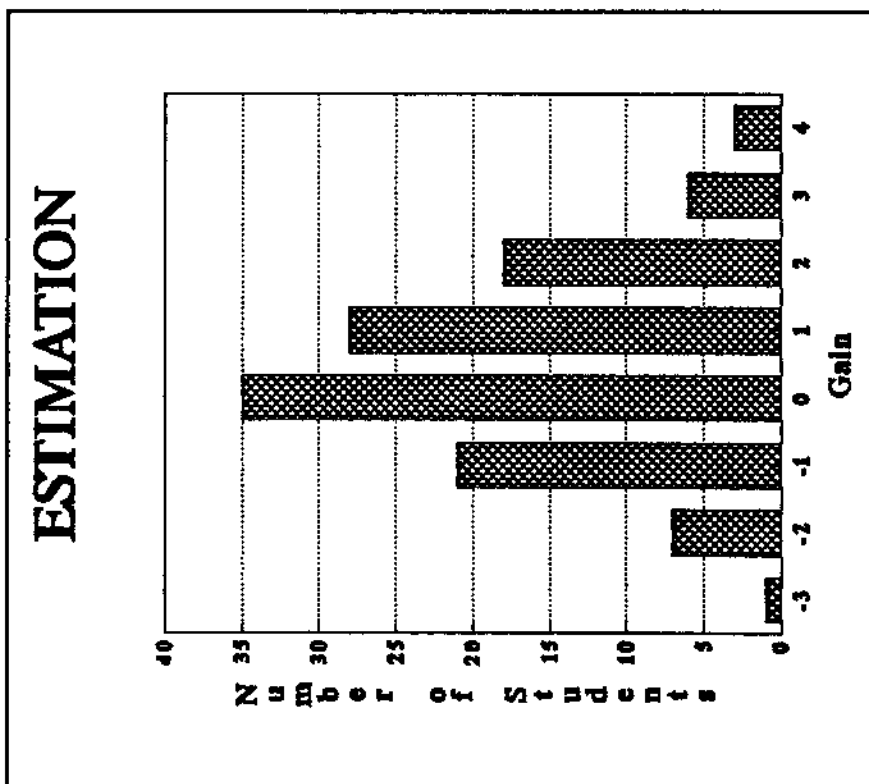
GRAPH 4 - TOTAL GAINS



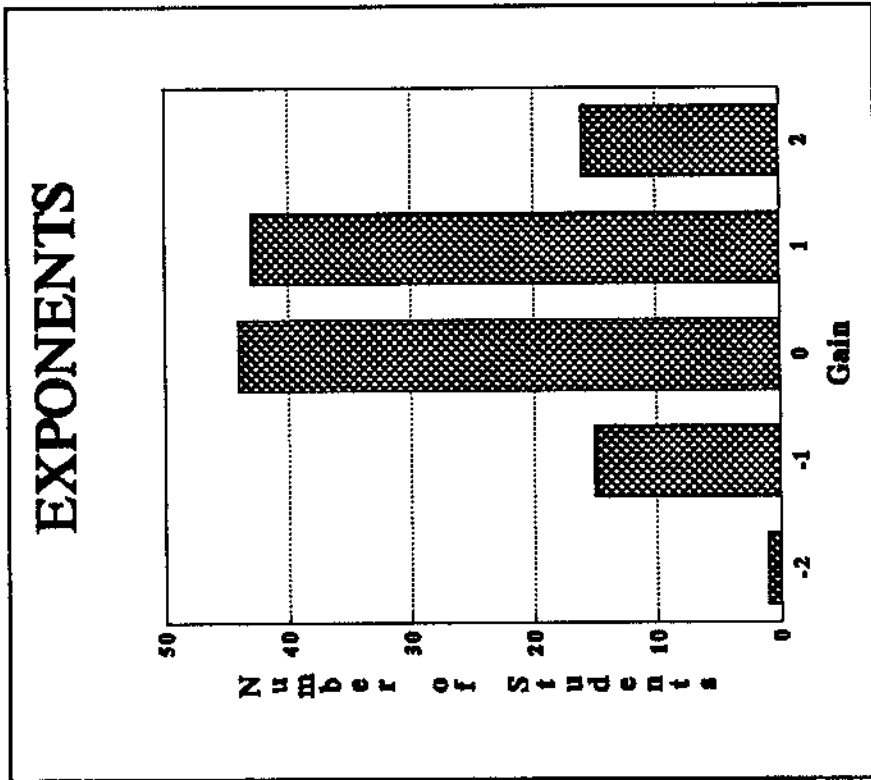
GRAPH 3 - TOTAL GAINS



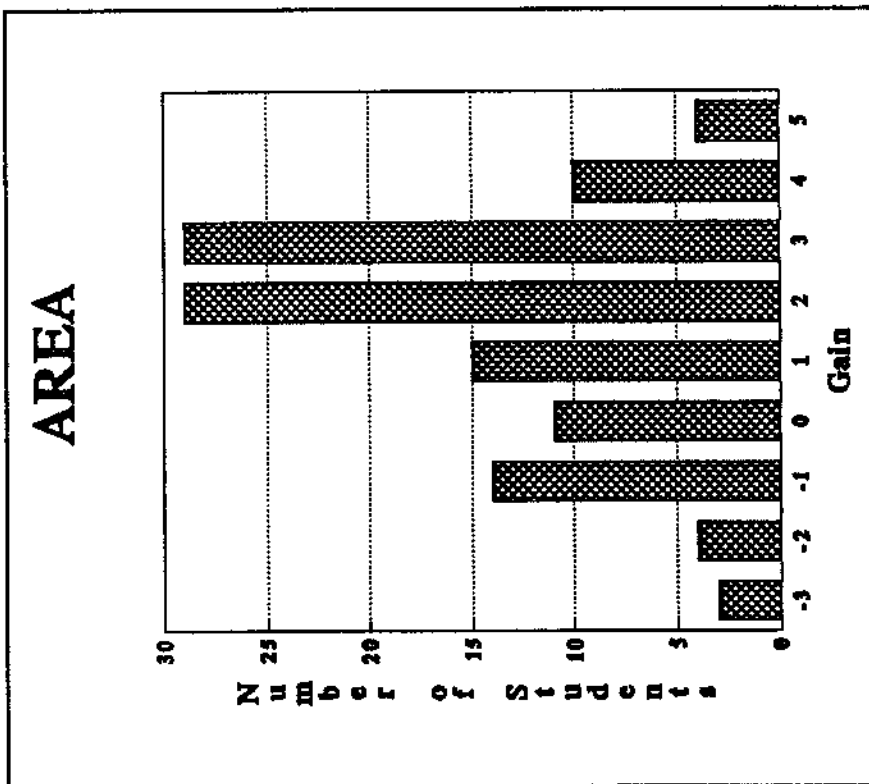
GRAPH 6 - TOTAL GAINS



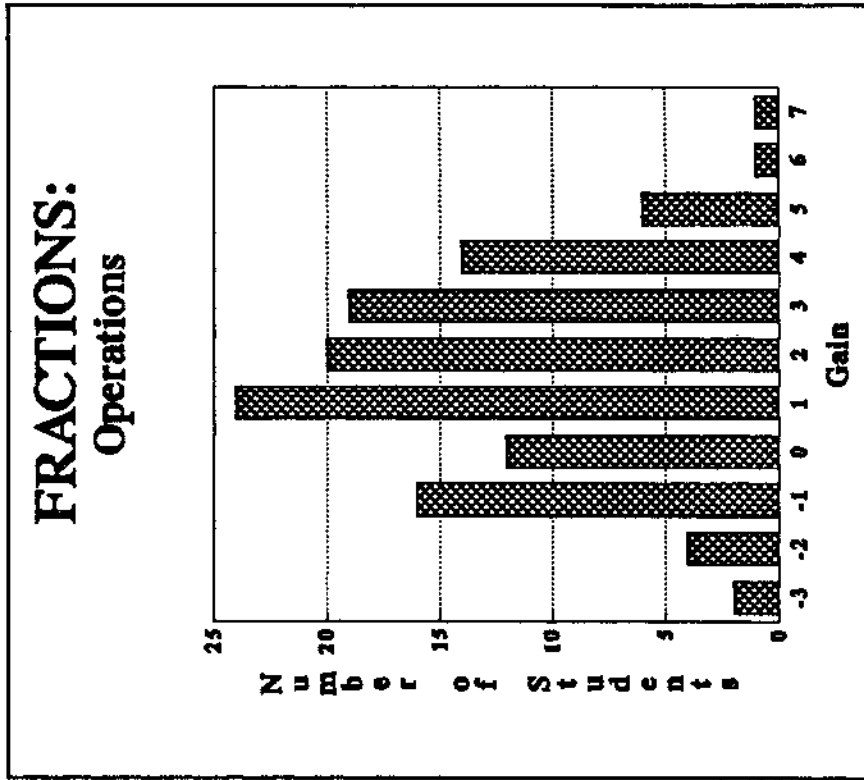
GRAPH 5 - TOTAL GAINS



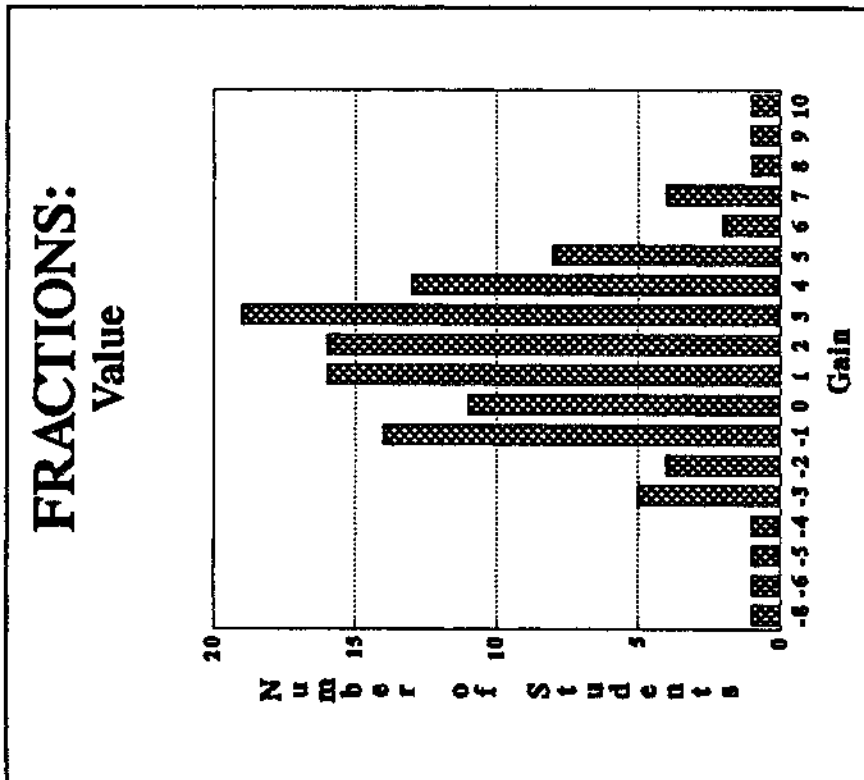
GRAPH 8 - TOTAL GAINS



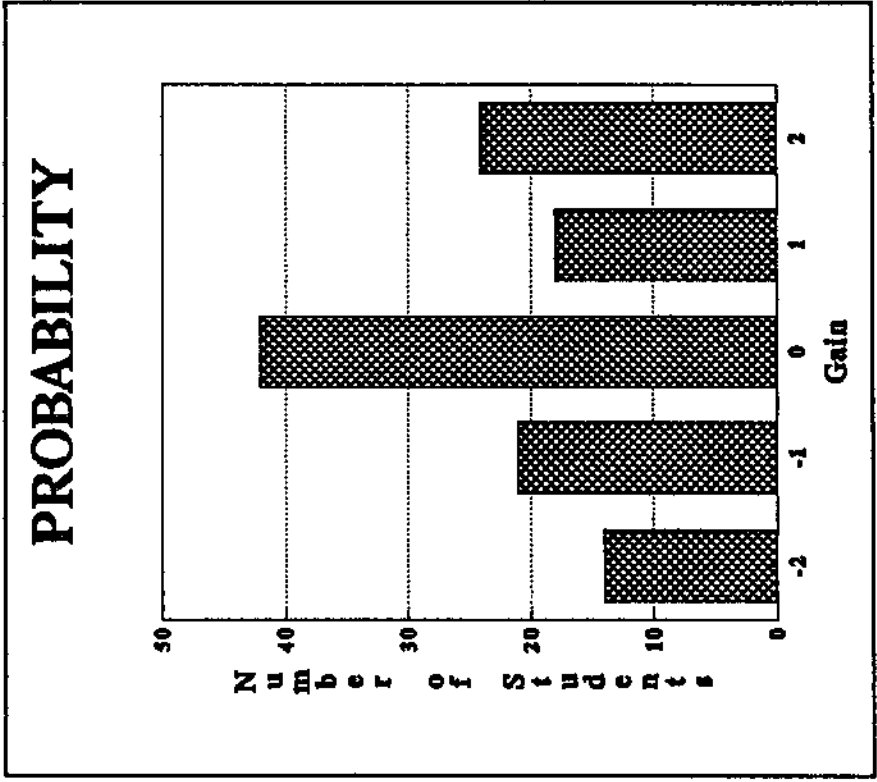
GRAPH 7 - TOTAL GAINS



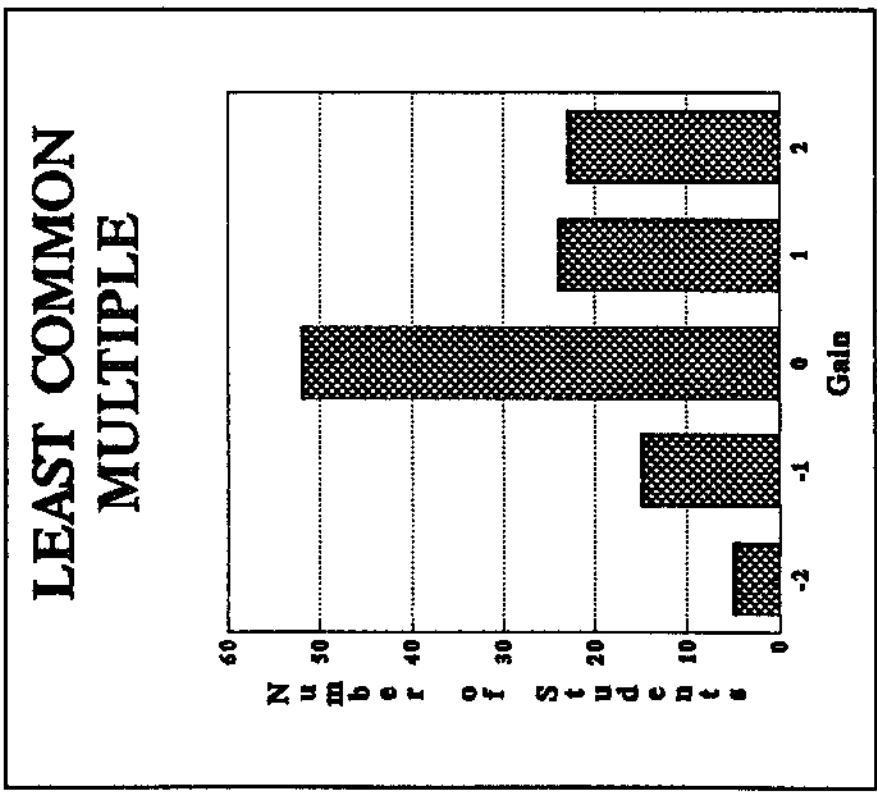
GRAPH 10 - TOTAL GAINS



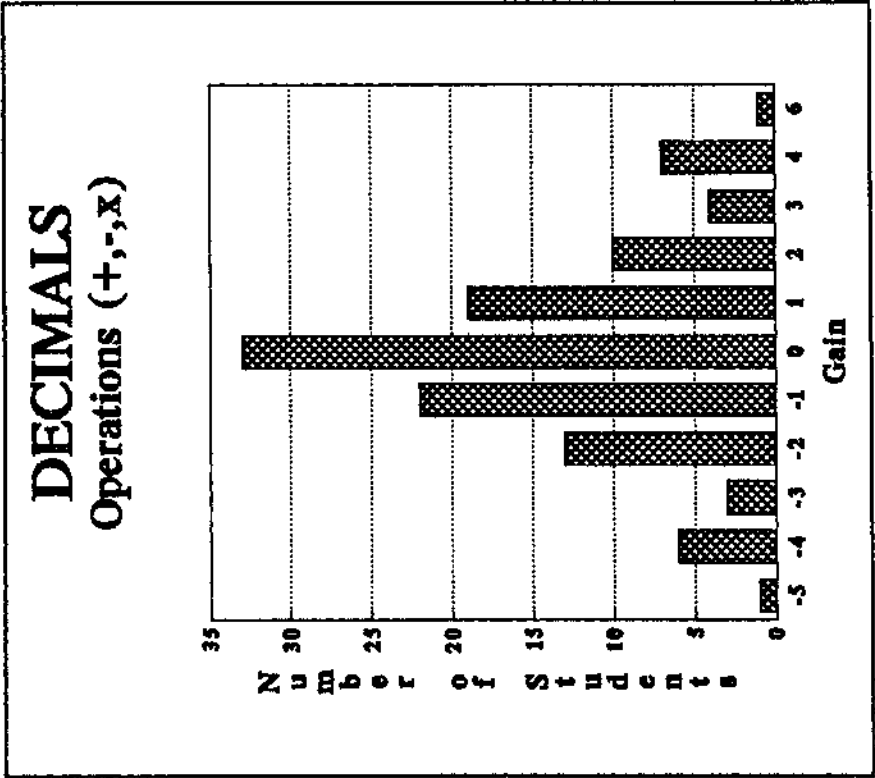
GRAPH 9 - TOTAL GAINS



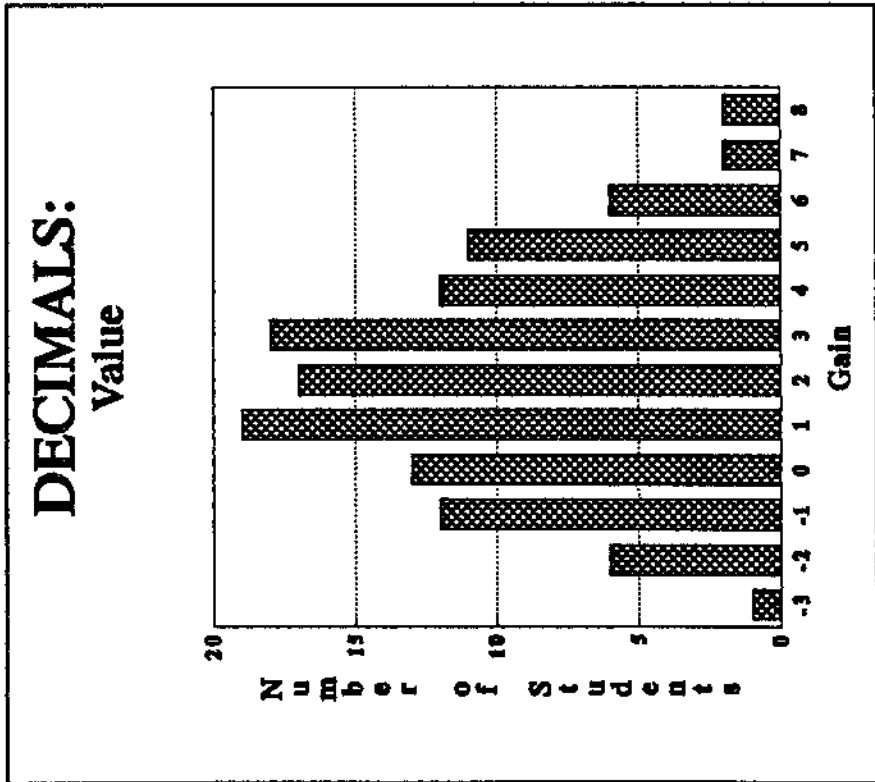
GRAPH 12 - TOTAL GAINS



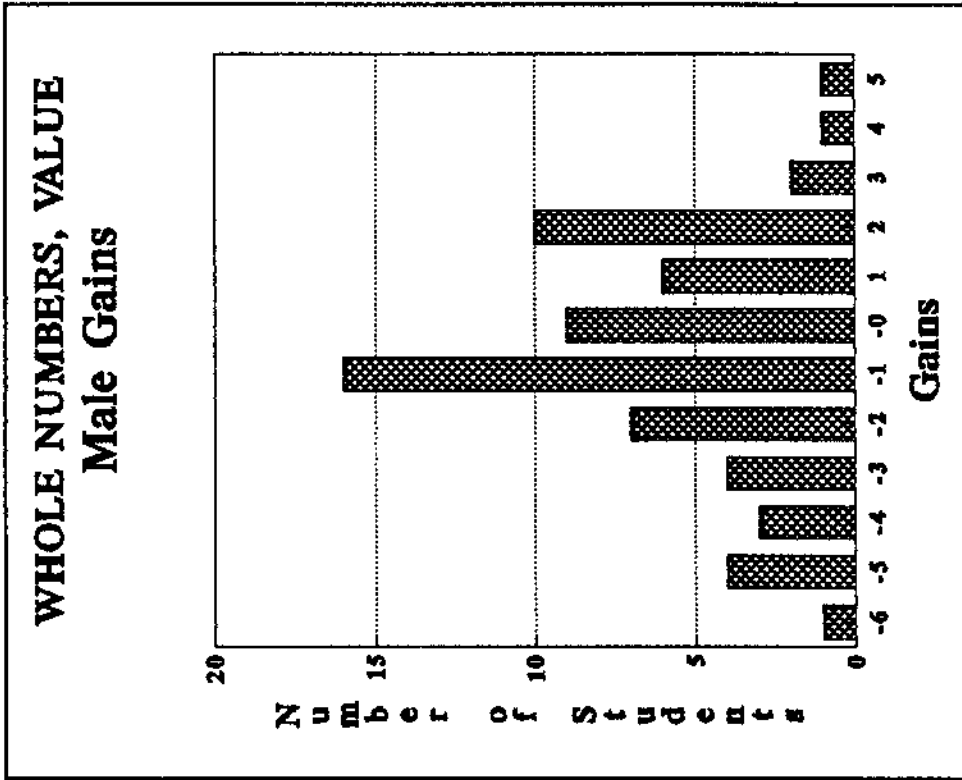
GRAPH 11 - TOTAL GAINS



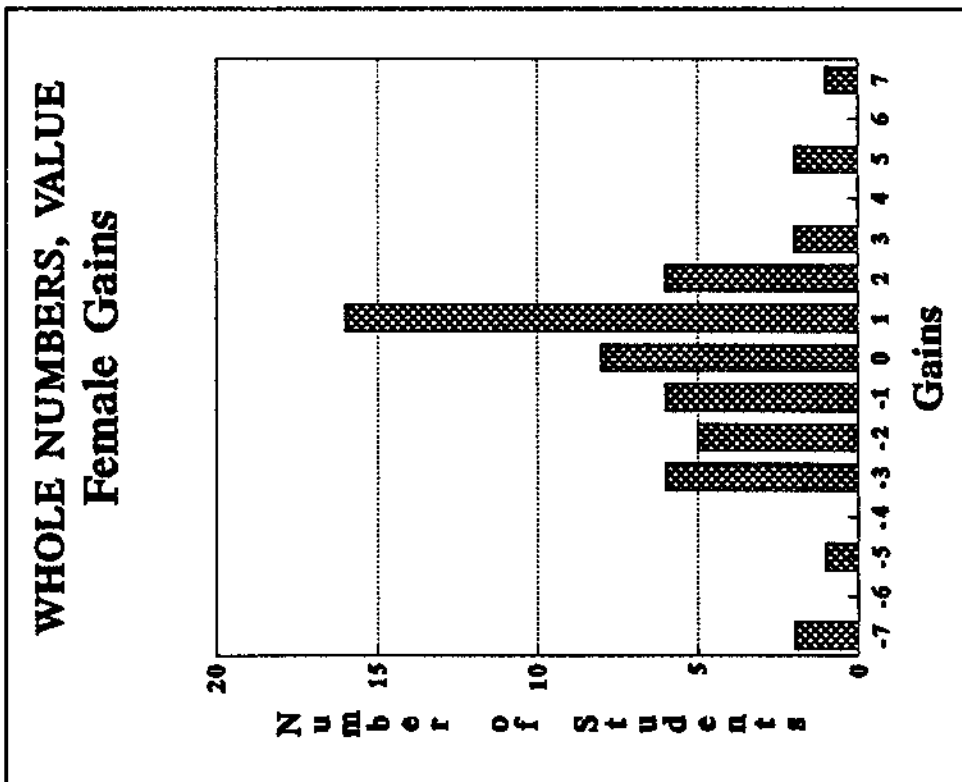
GRAPH 14 - TOTAL GAINS



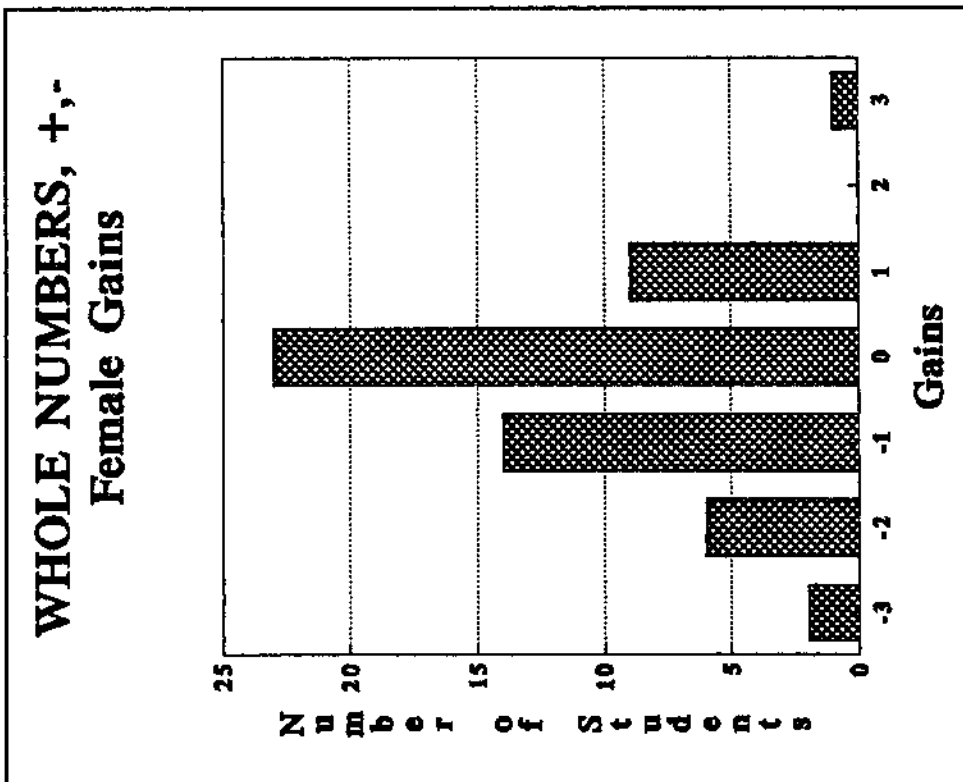
GRAPH 13 - TOTAL GAINS



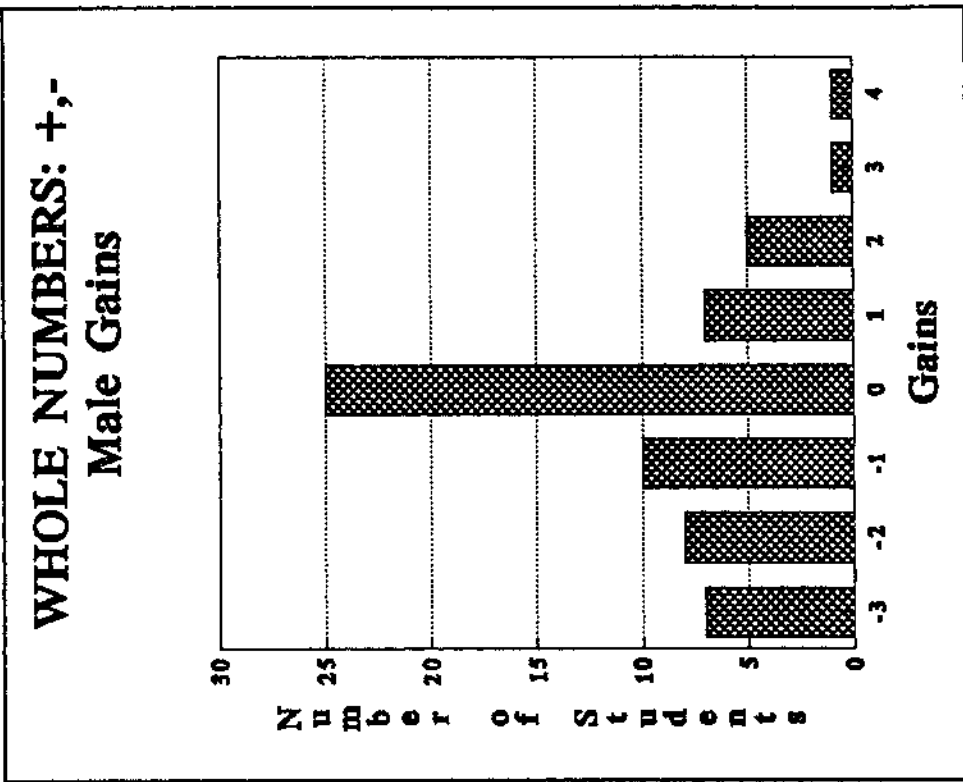
GRAPH 16 - GAINS BY GENDER



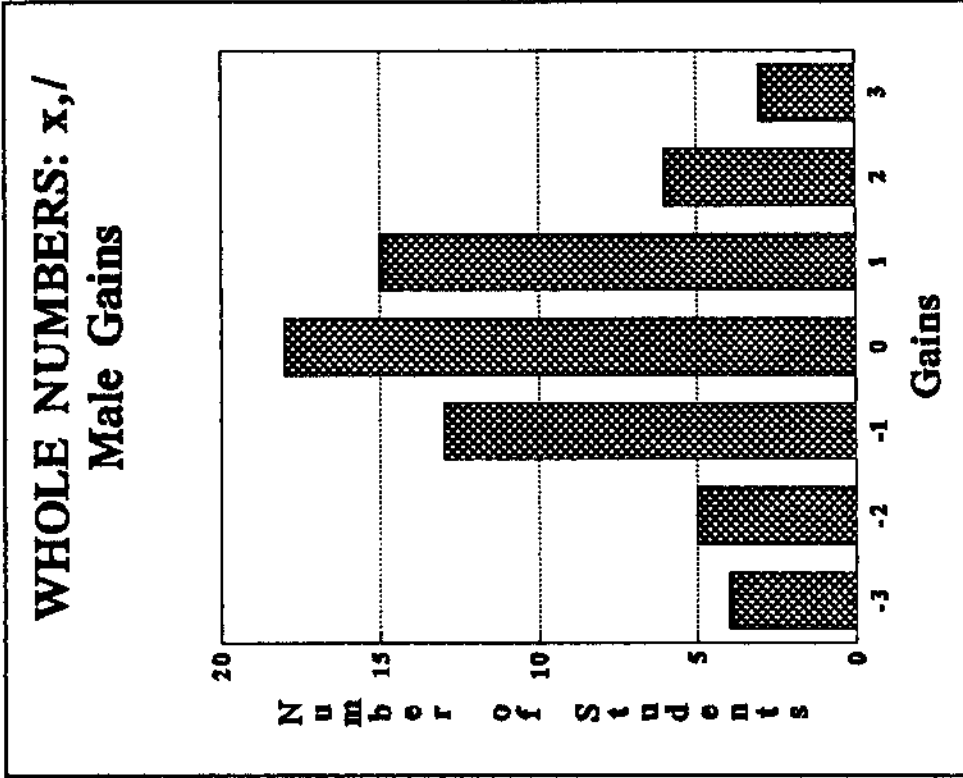
GRAPH 15 - GAINS BY GENDER



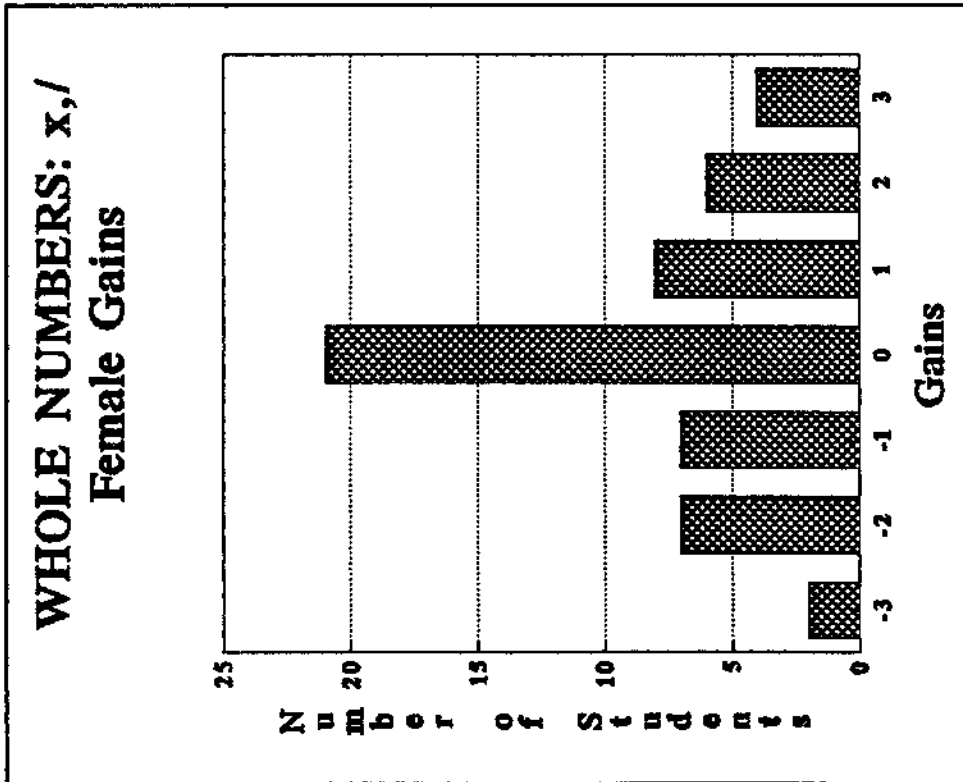
GRAPH 17 - GAINS BY GENDER



GRAPH 18 - GAINS BY GENDER



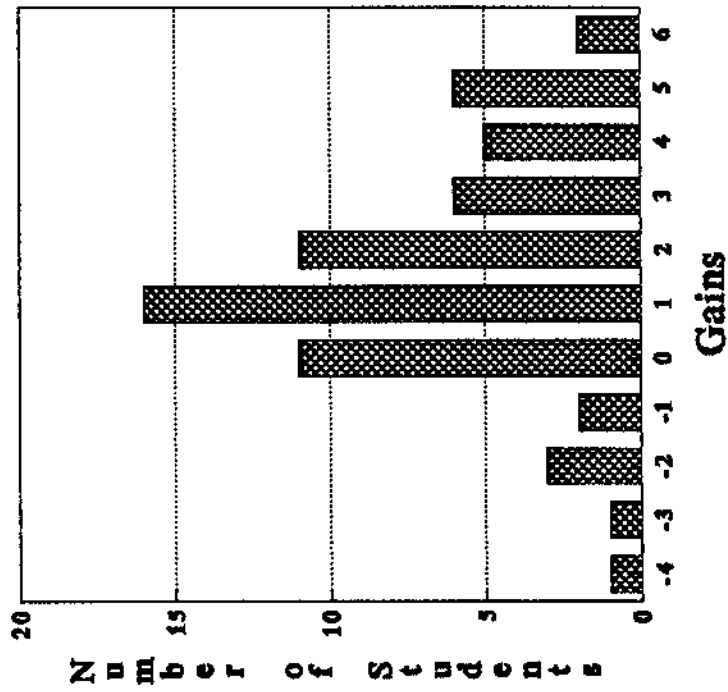
GRAPH 20 - GAINS BY GENDER



GRAPH 19 - GAINS BY GENDER

WORD PROBLEMS

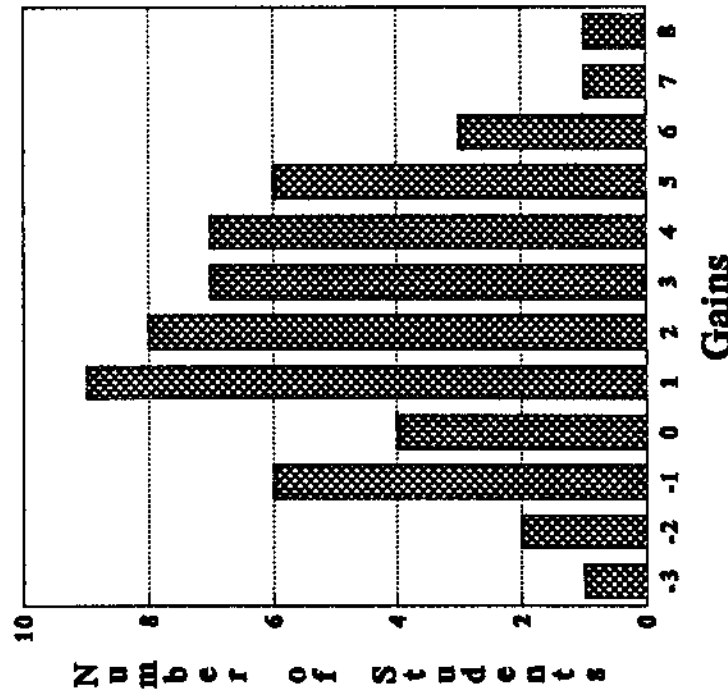
Male Gains



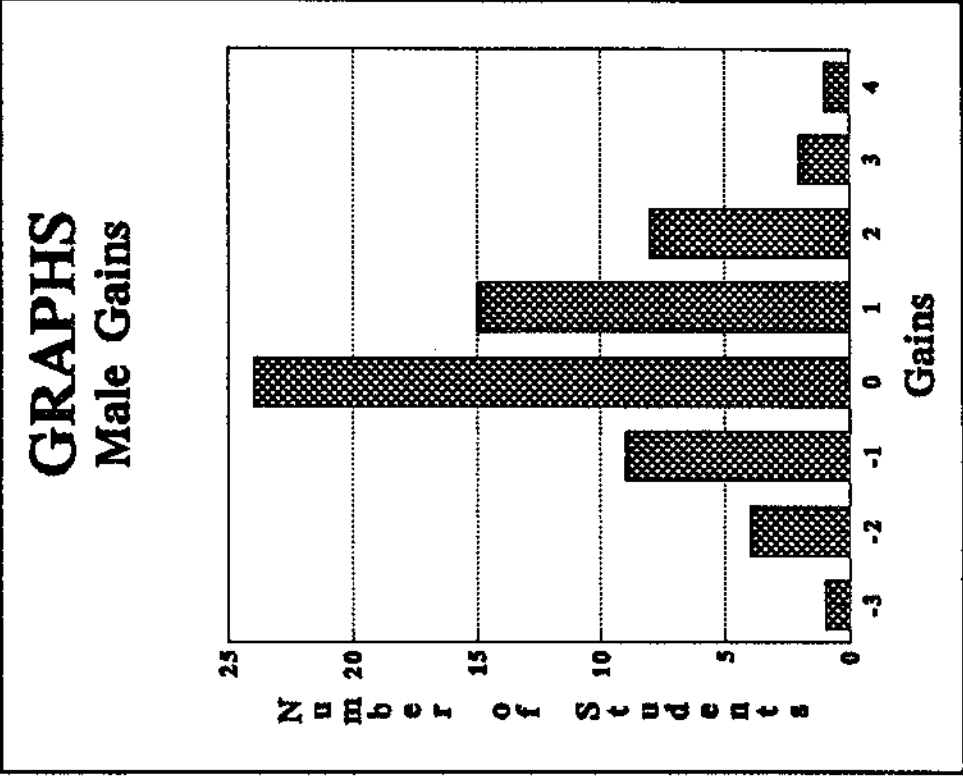
GRAPH 22 - GAINS BY GENDER

WORD PROBLEMS

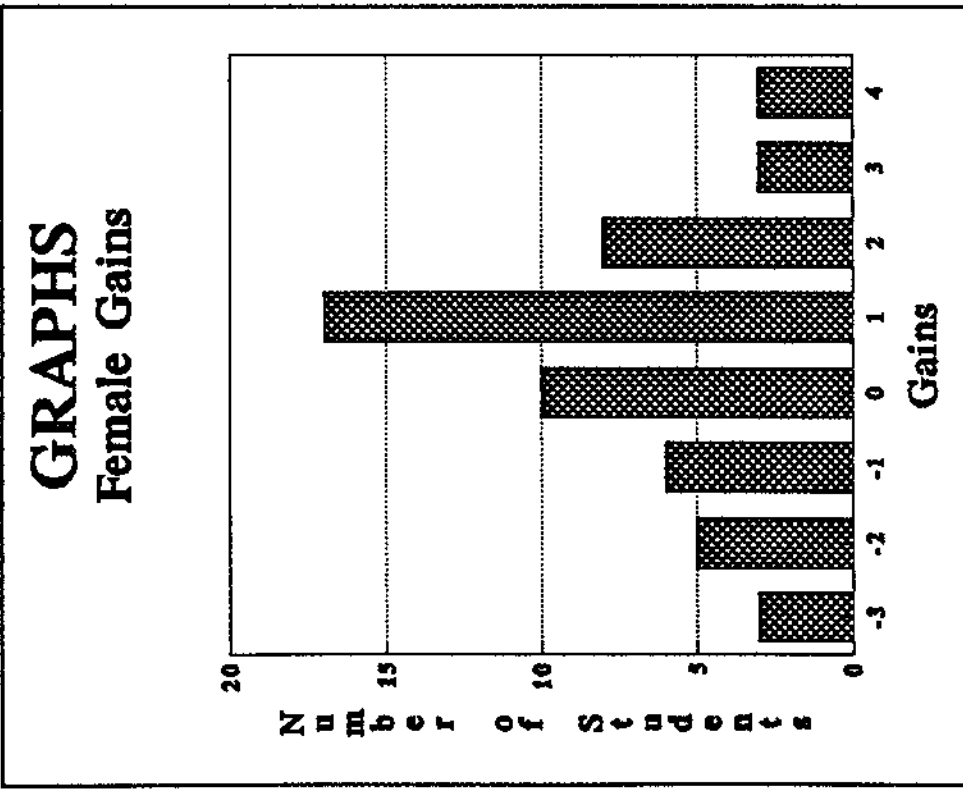
Female Gains



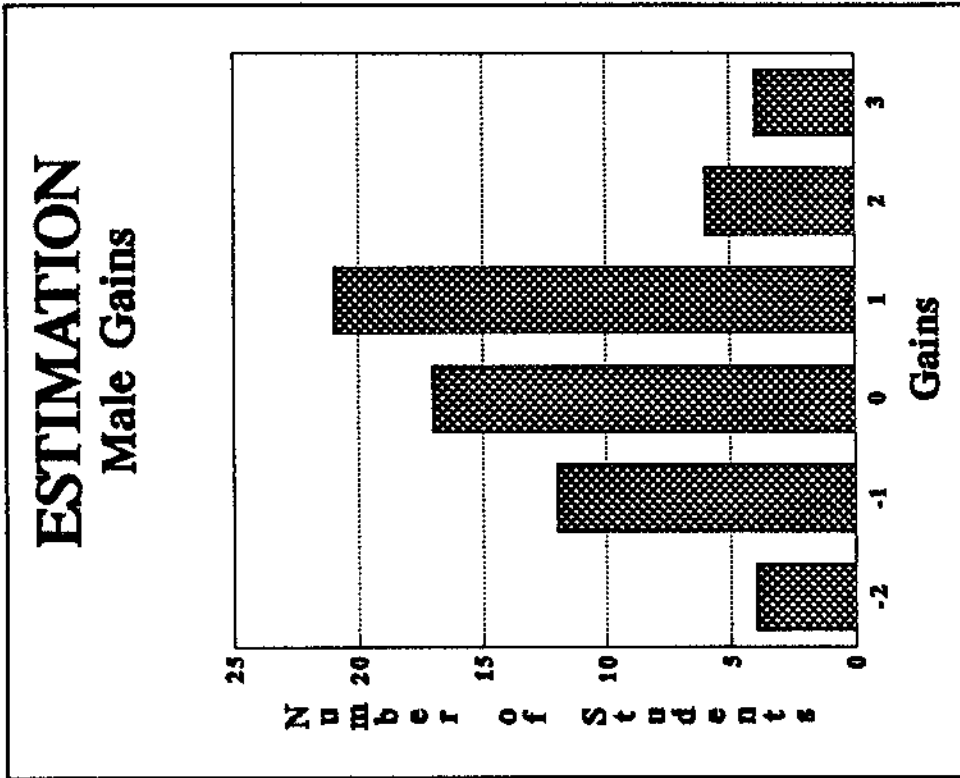
GRAPH 21 - GAINS BY GENDER



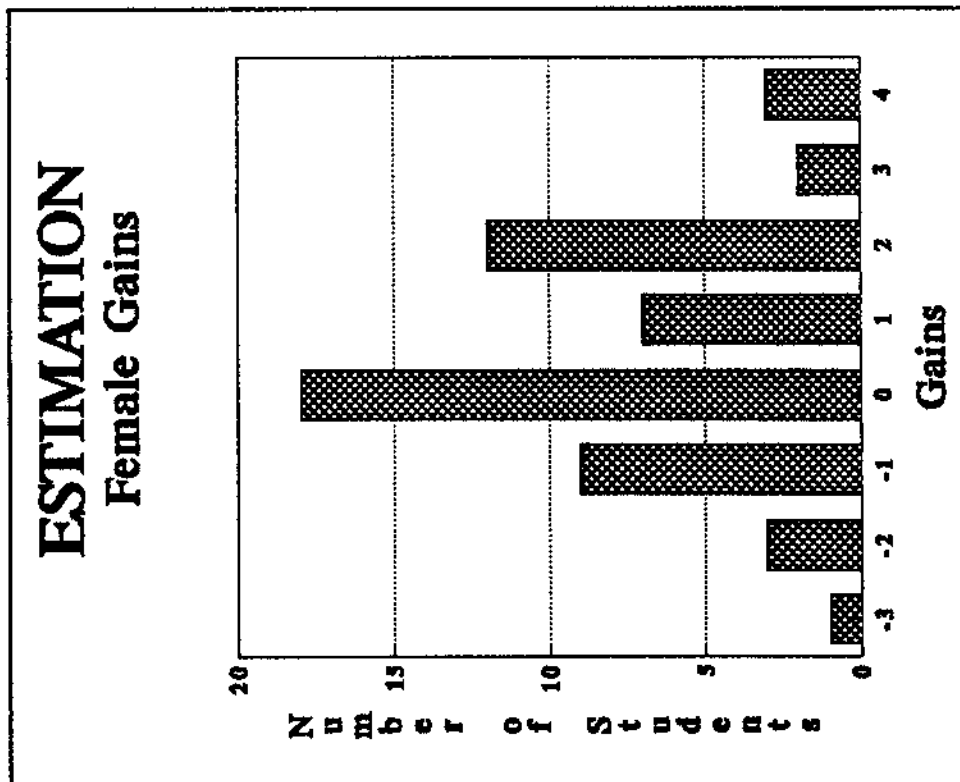
GRAPH 24 - GAINS BY GENDER



GRAPH 23 - GAINS BY GENDER



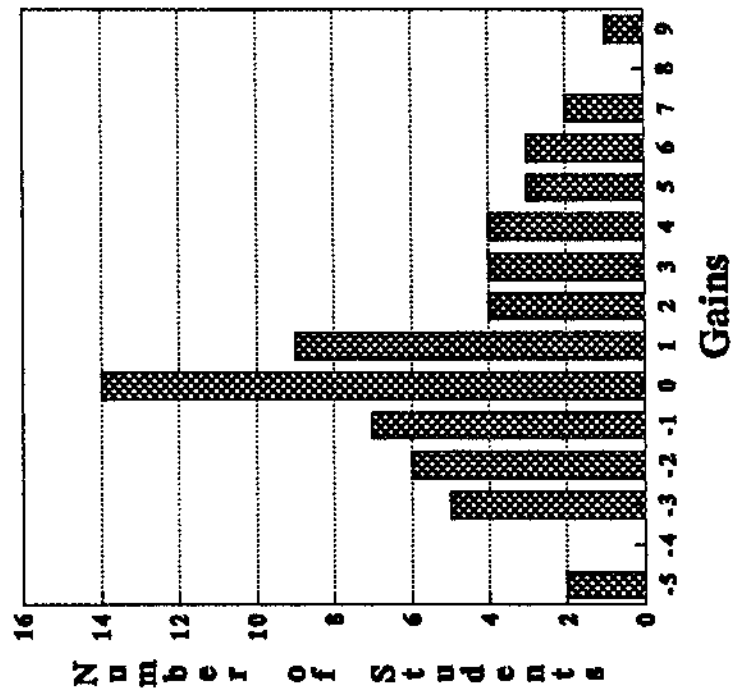
GRAPH 26 - GAINS BY GENDER



GRAPH 25 - GAINS BY GENDER

MEASUREMENT

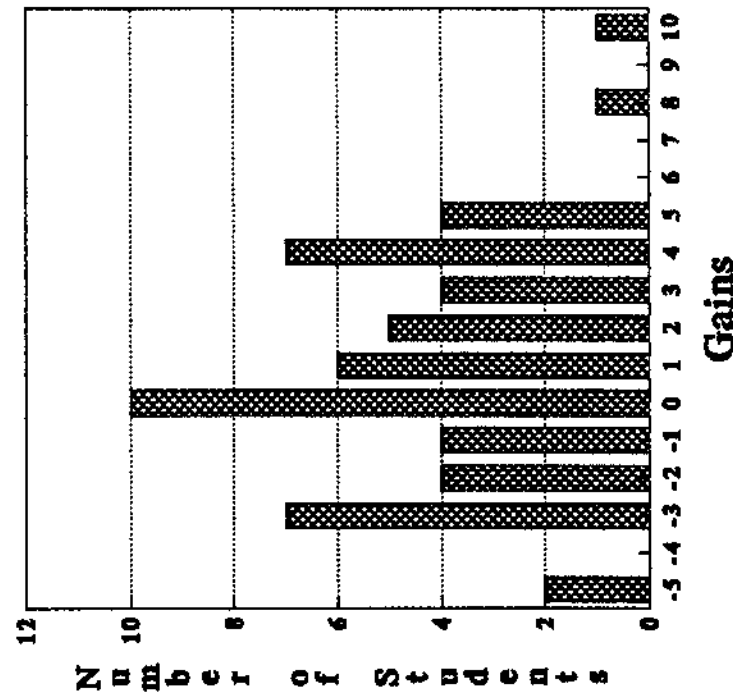
Male Gains



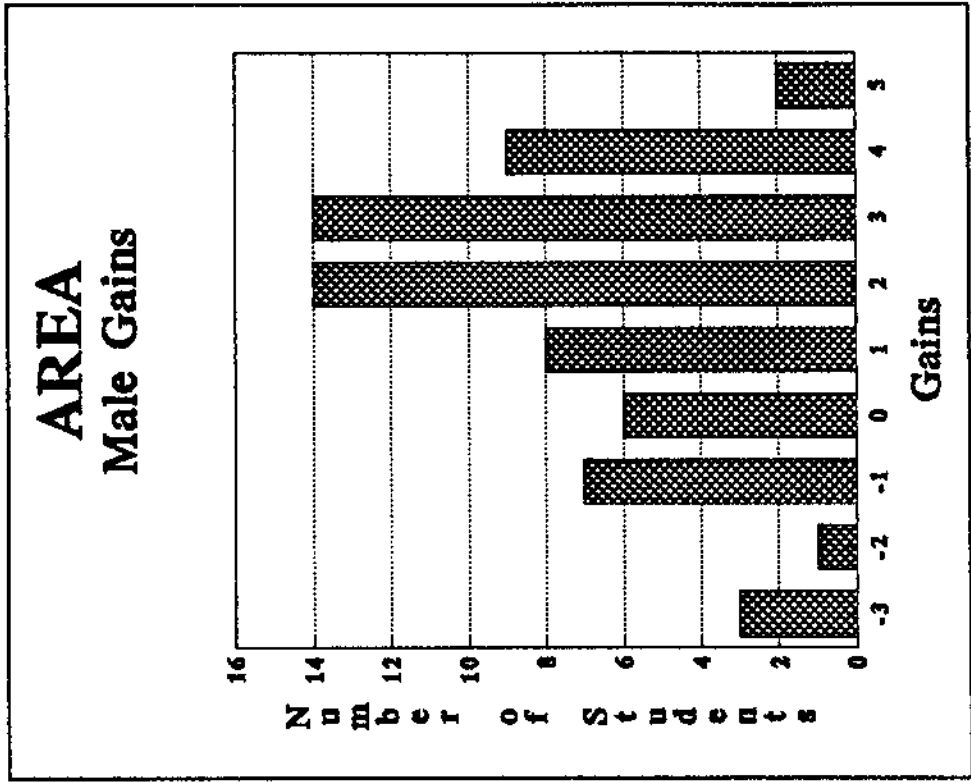
GRAPH 28 - GAINS BY GENDER

MEASUREMENT

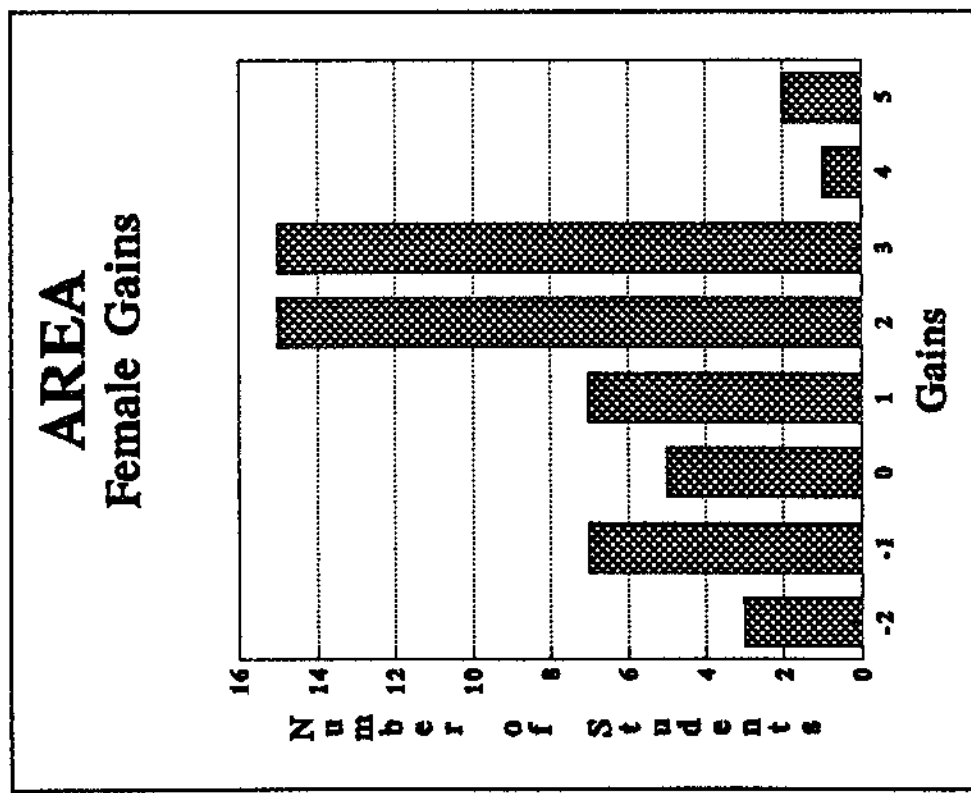
Female Gains



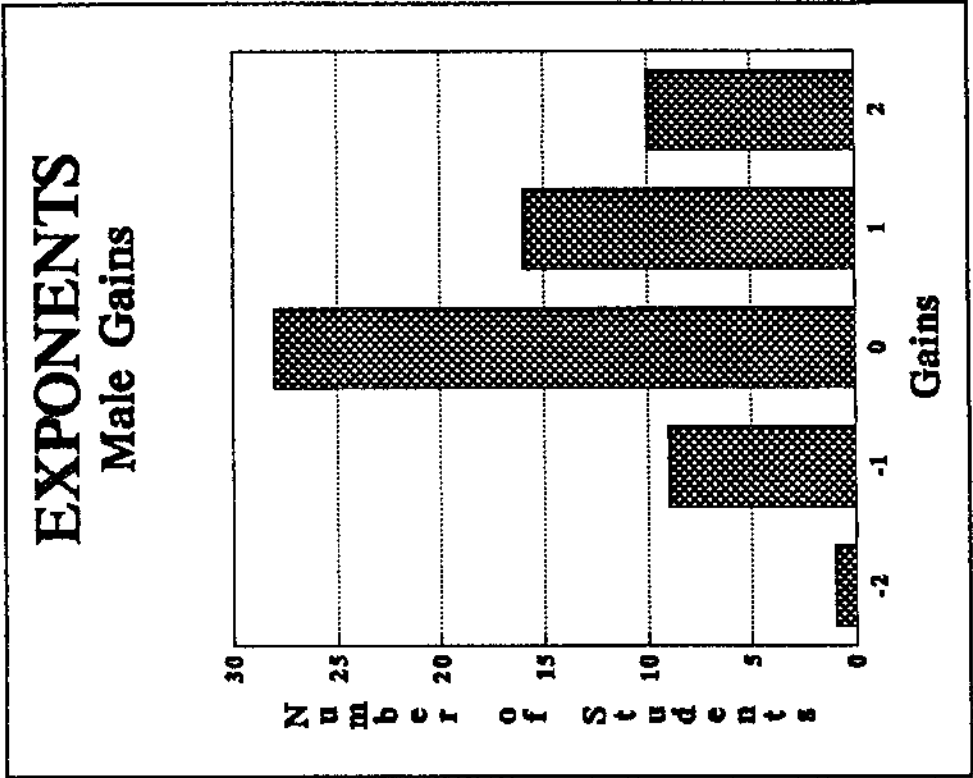
GRAPH 27 - GAINS BY GENDER



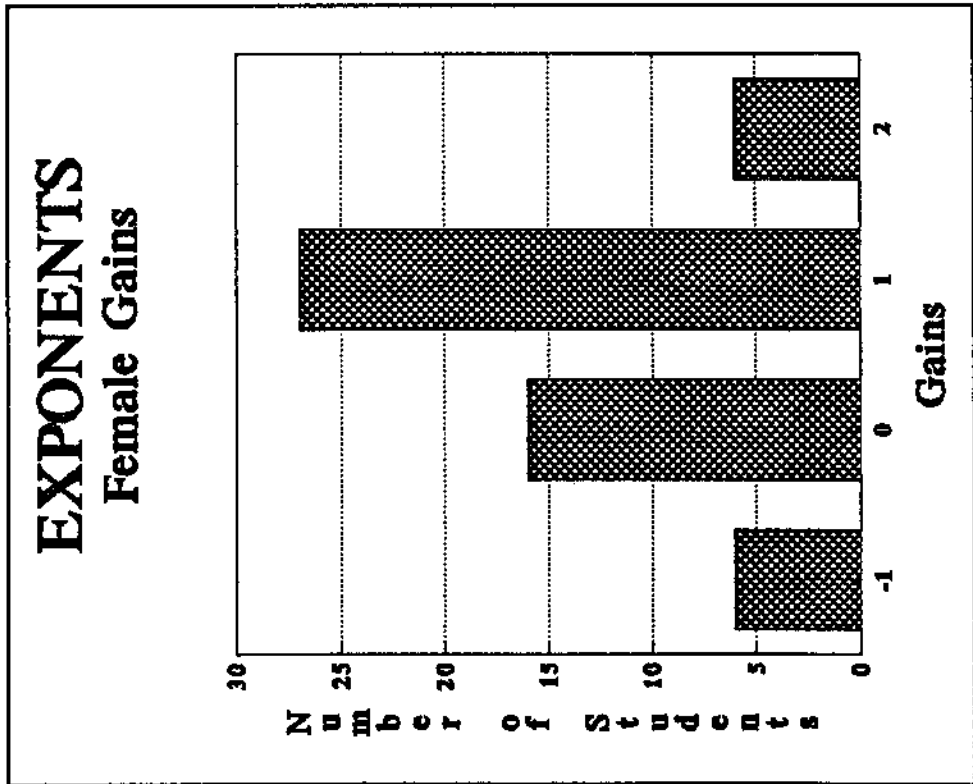
GRAPH 30 - GAINS BY GENDER



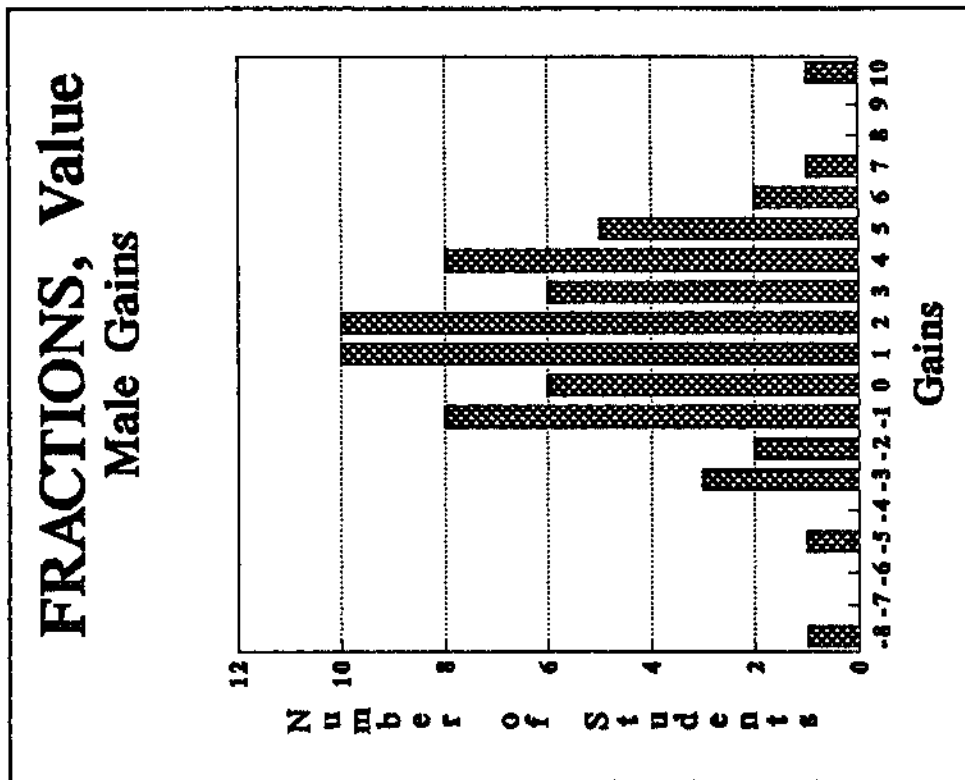
GRAPH 29 - GAINS BY GENDER



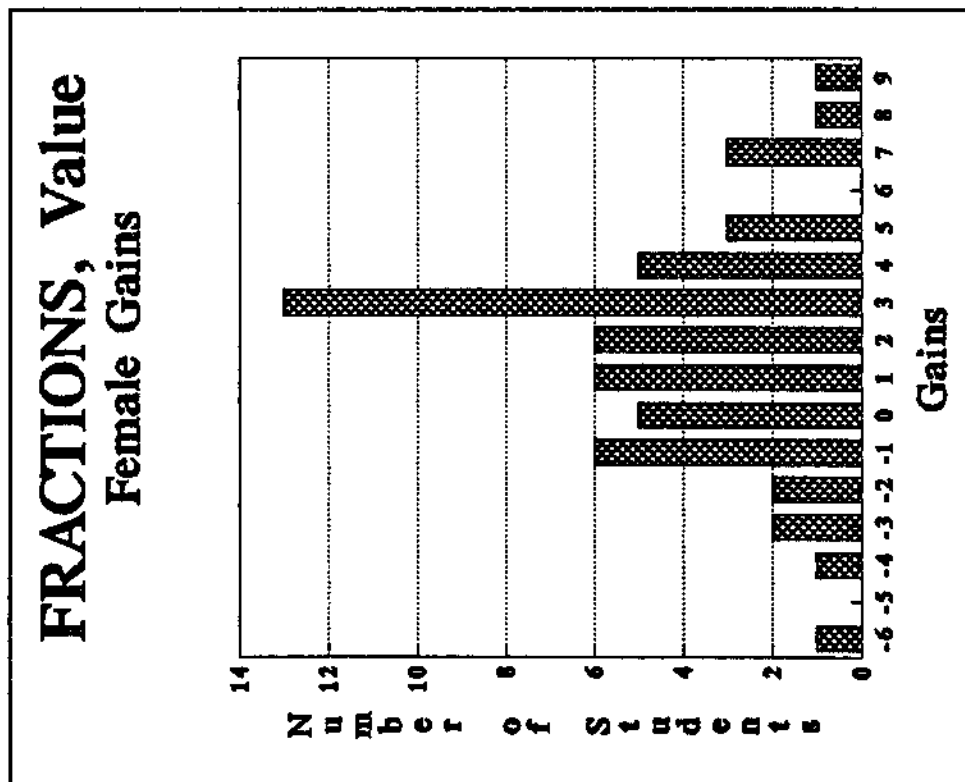
GRAPH 32 - GAINS BY GENDER



GRAPH 31 - GAINS BY GENDER

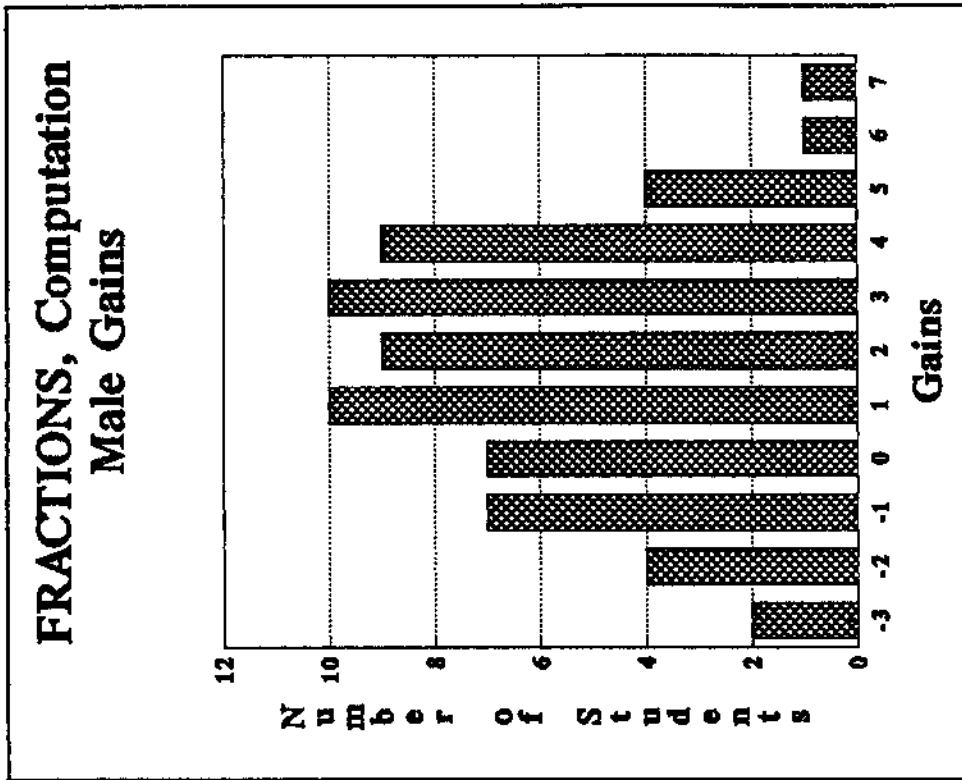


GRAPH 34 - GAINS BY GENDER

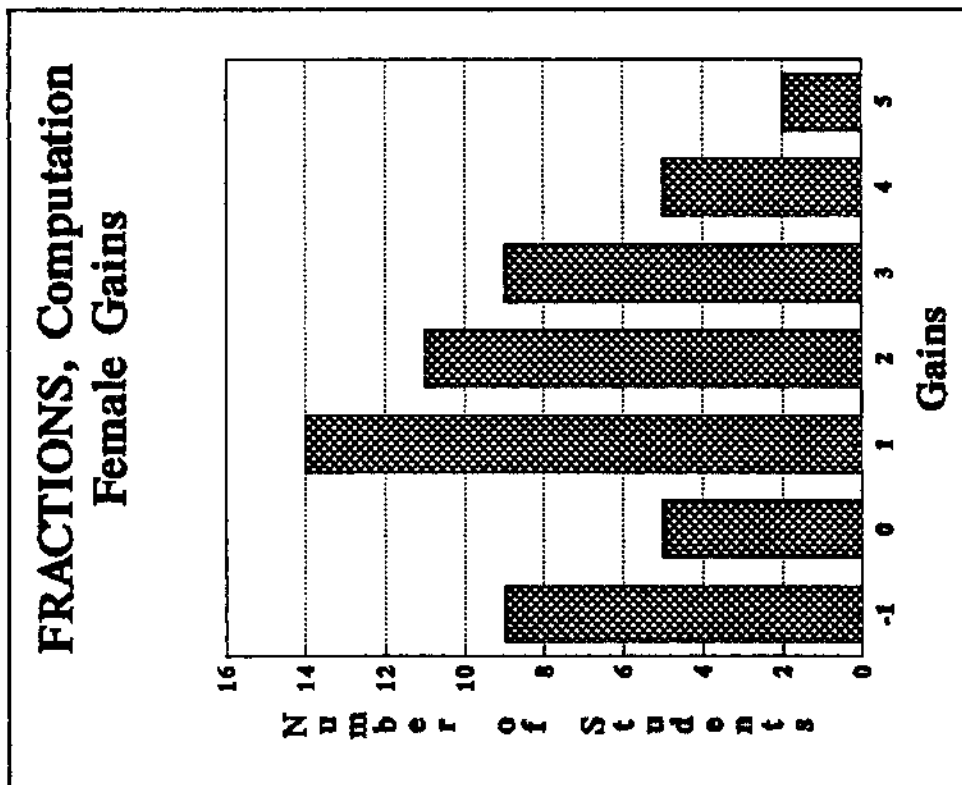


GRAPH 33 - GAINS BY GENDER

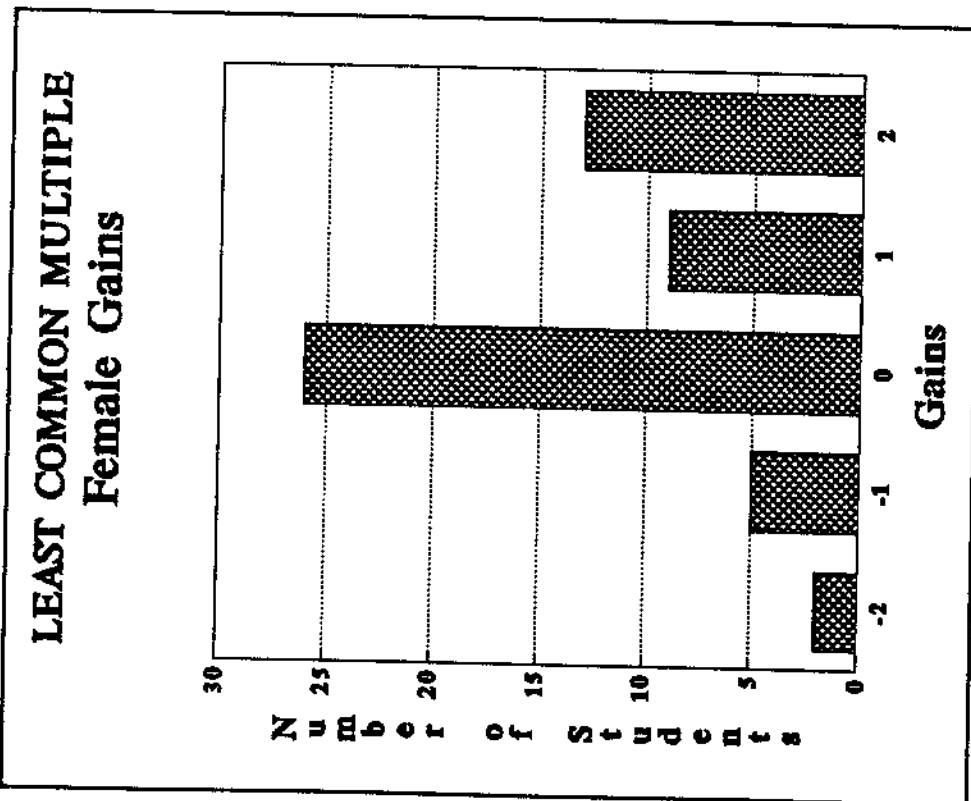
*



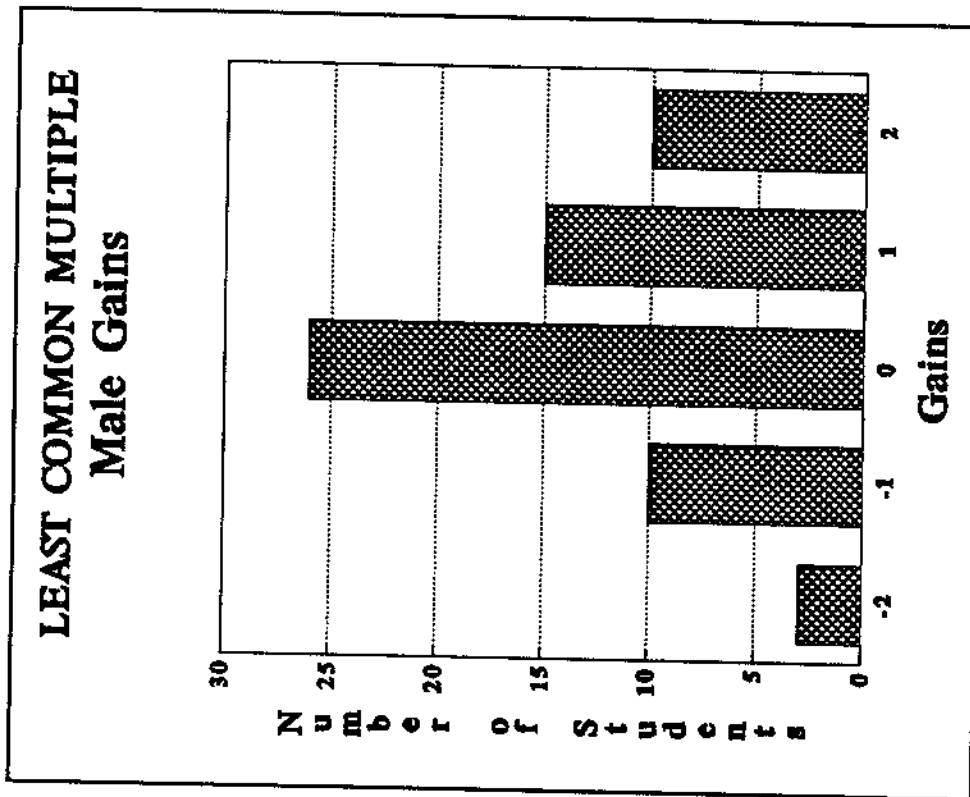
GRAPH 36 - GAINS BY GENDER



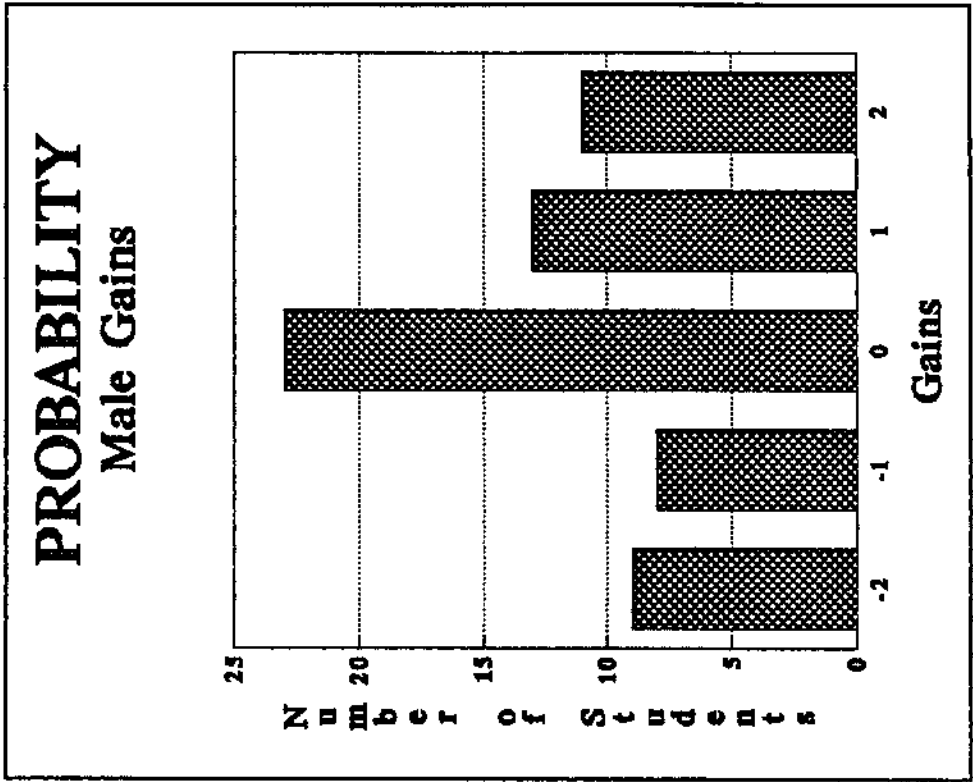
GRAPH 35 - GAINS BY GENDER



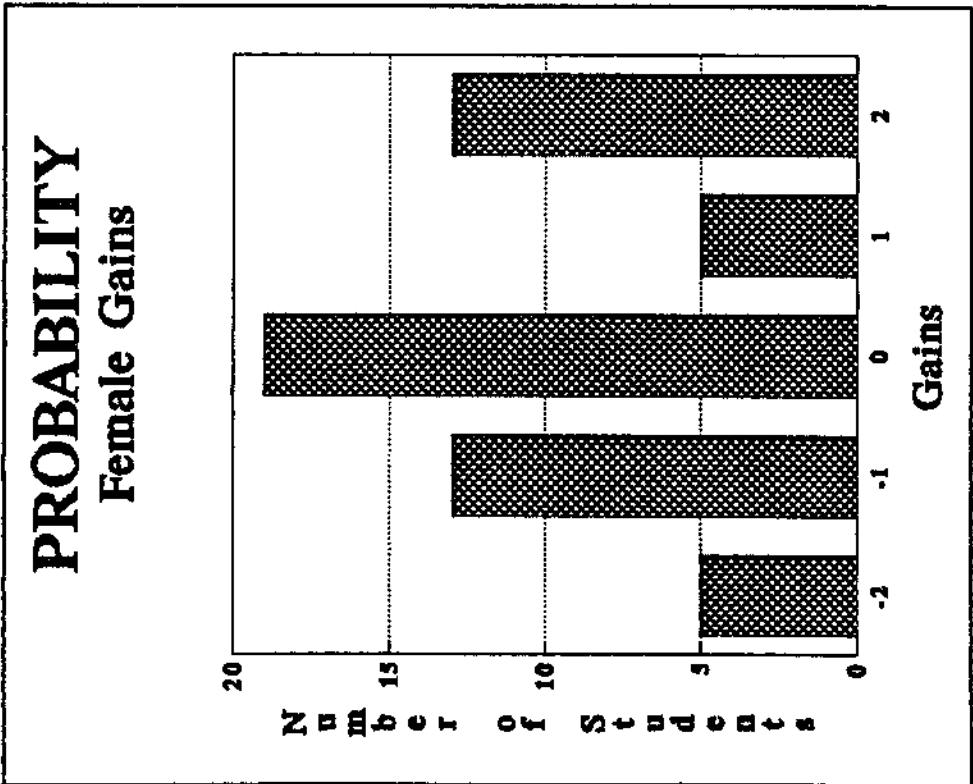
GRAPH 37 - GAINS BY GENDER



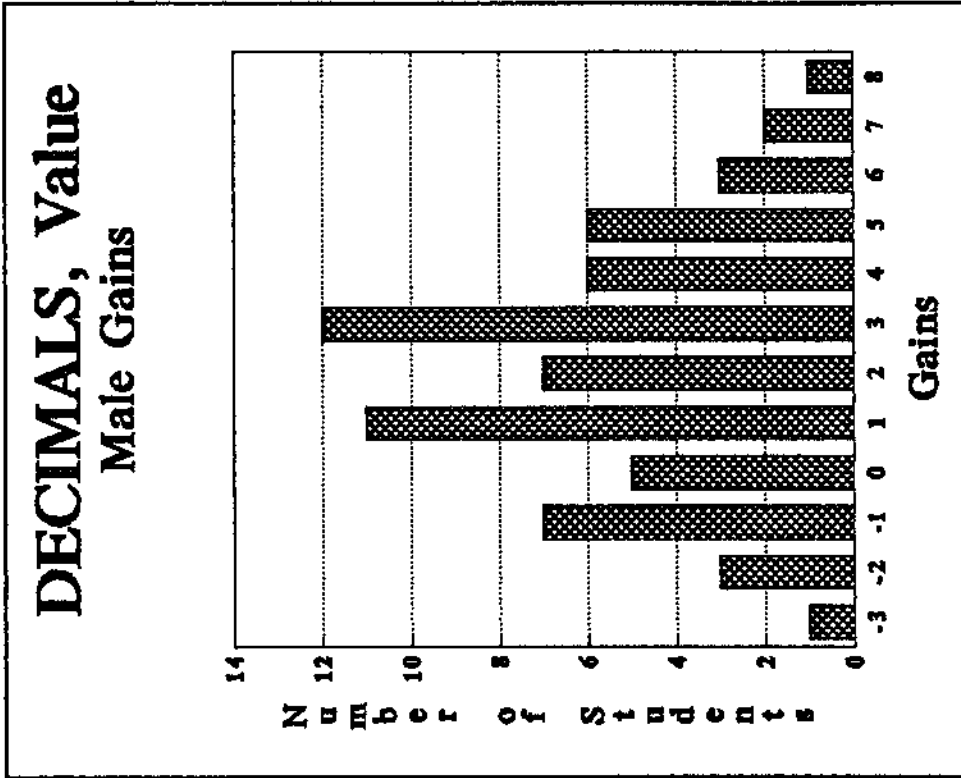
GRAPH 38 - GAINS BY GENDER



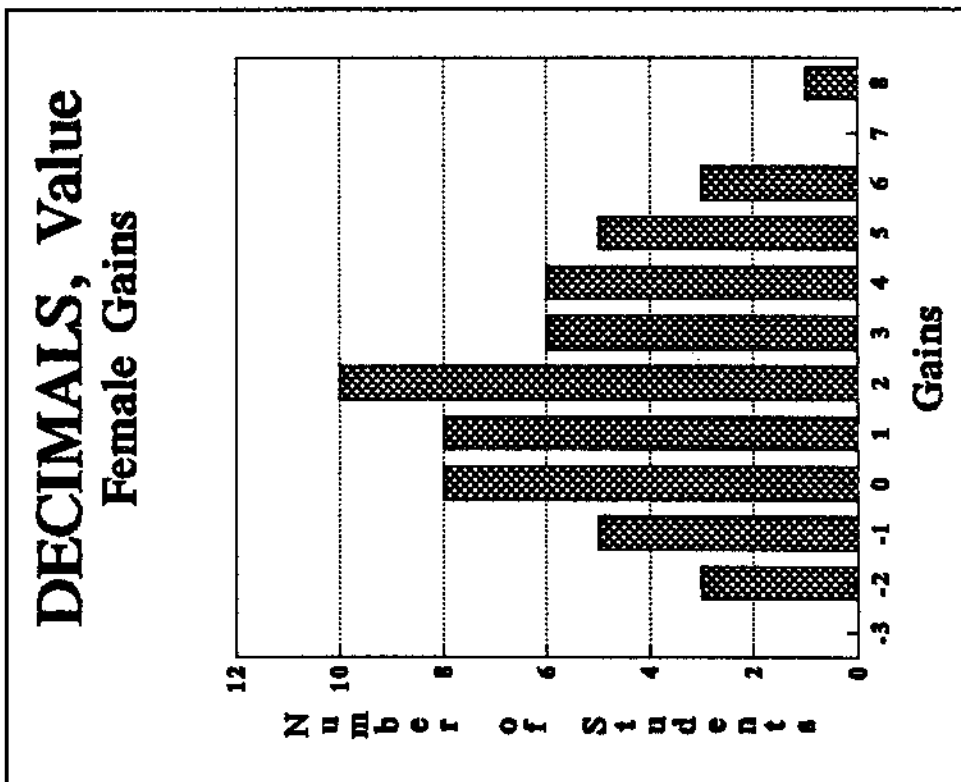
GRAPH 40 - GAINS BY GENDER



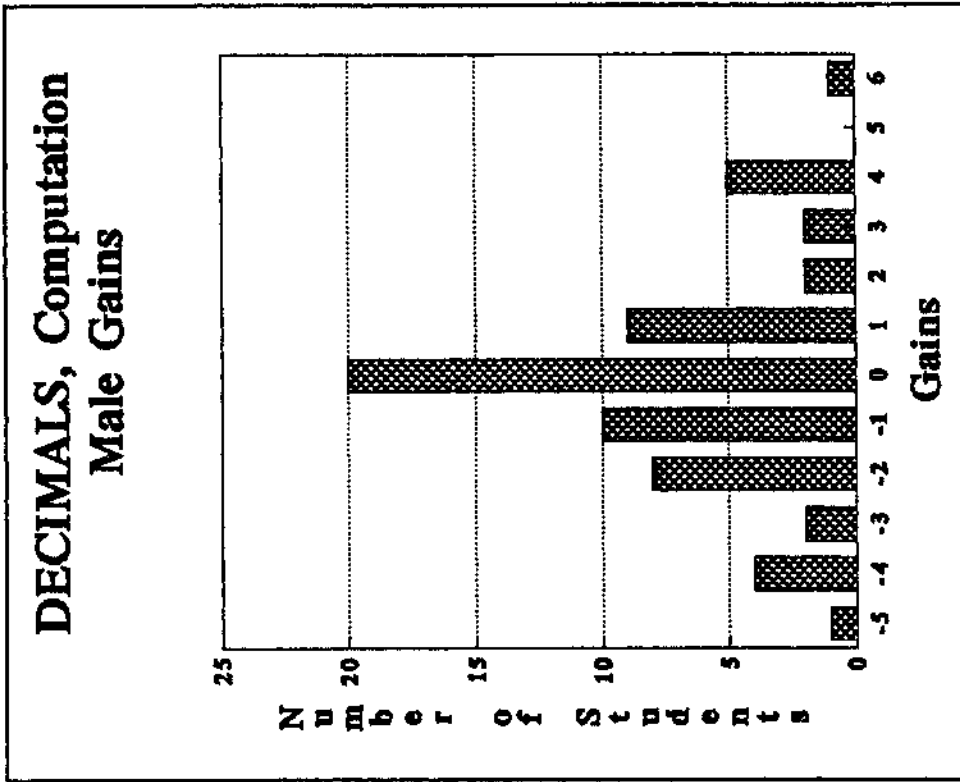
GRAPH 39 - GAINS BY GENDER



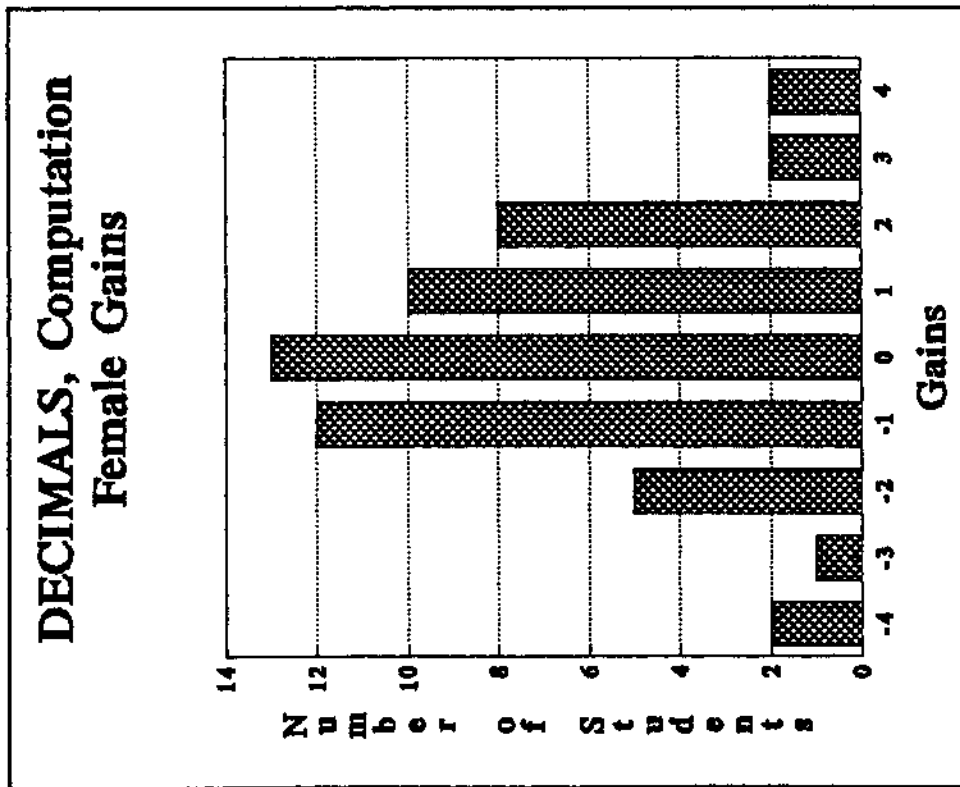
GRAPH 42 - GAINS BY GENDER



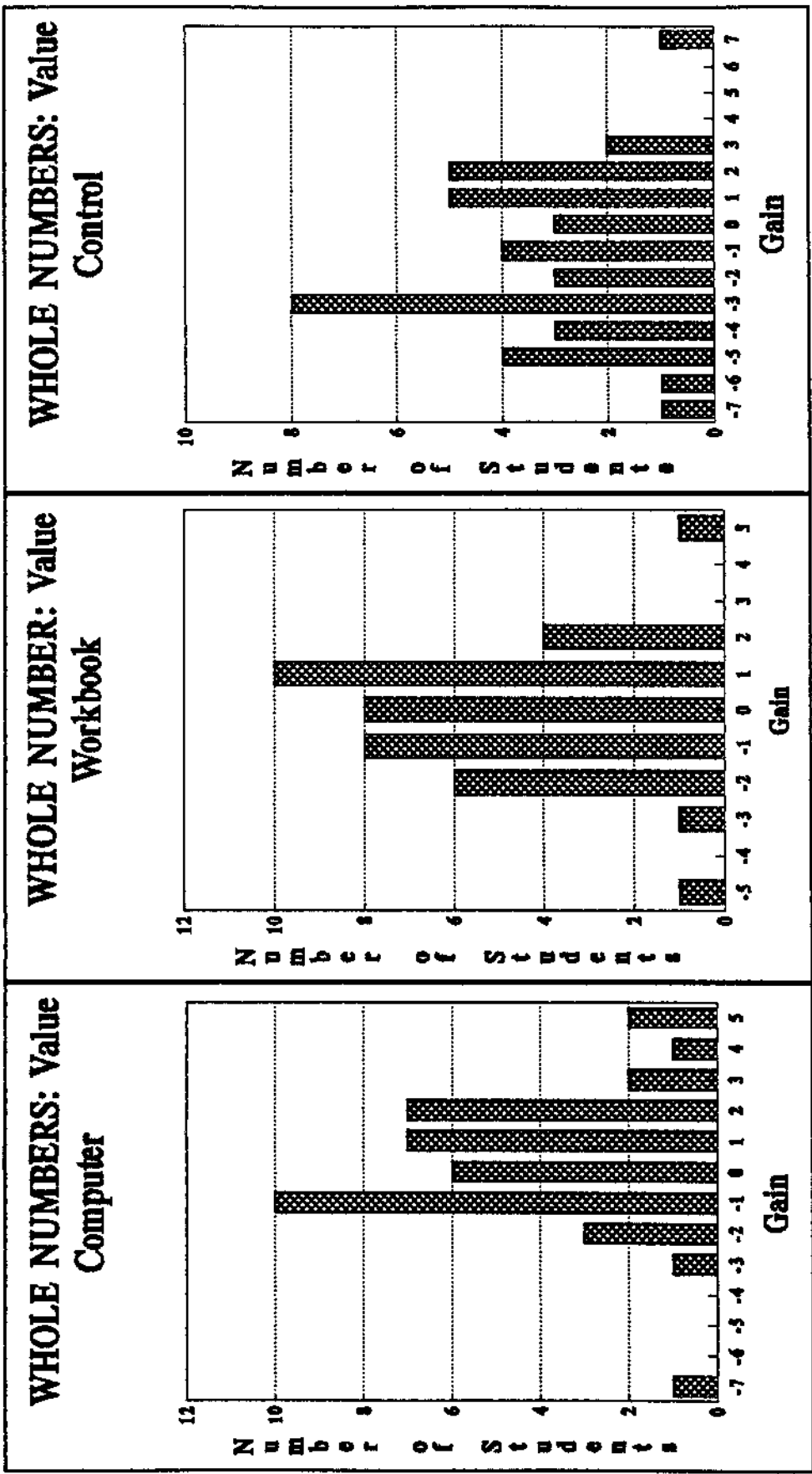
GRAPH 41 - GAINS BY GENDER



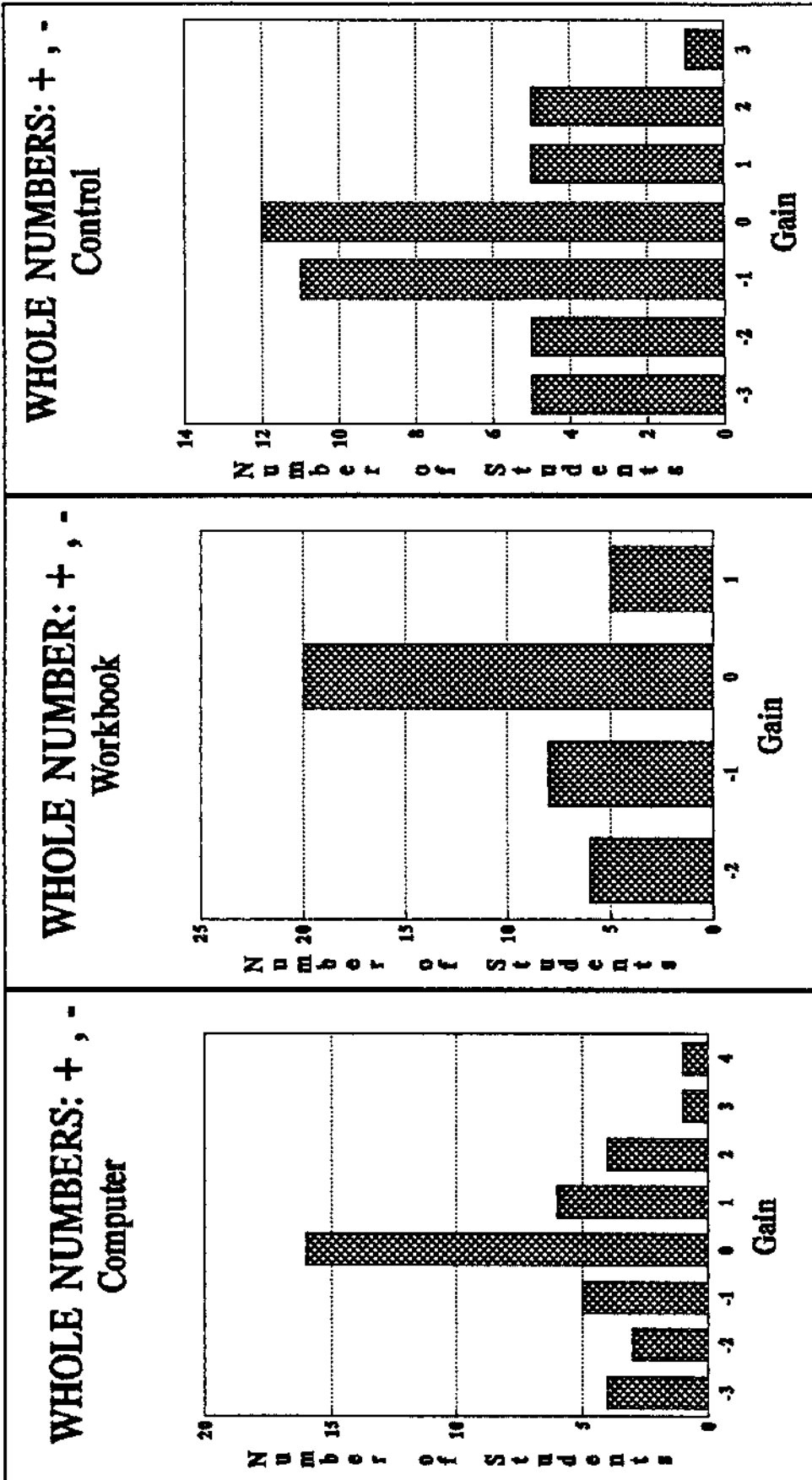
GRAPH 44 - GAINS BY GENDER



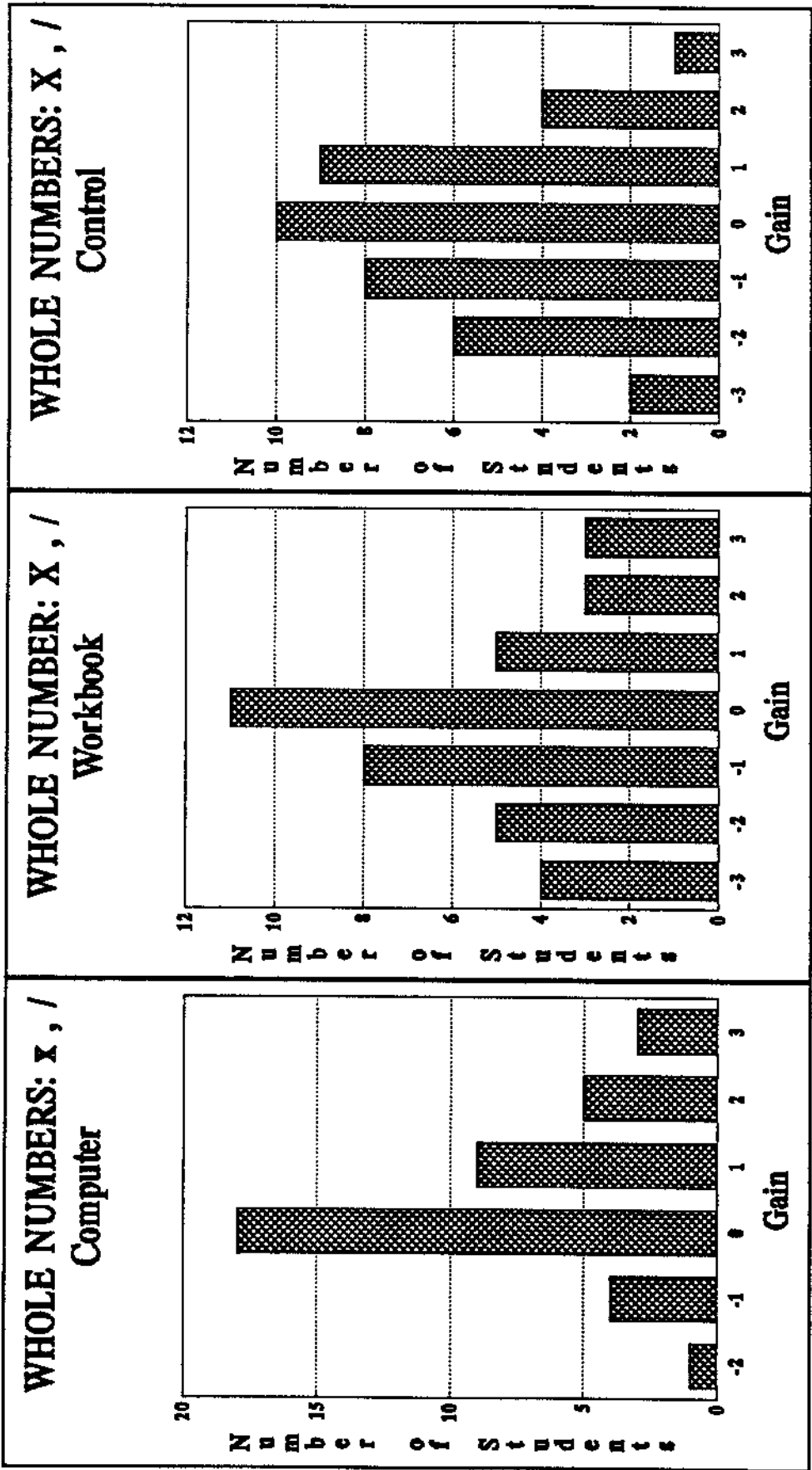
GRAPH 43 - GAINS BY GENDER



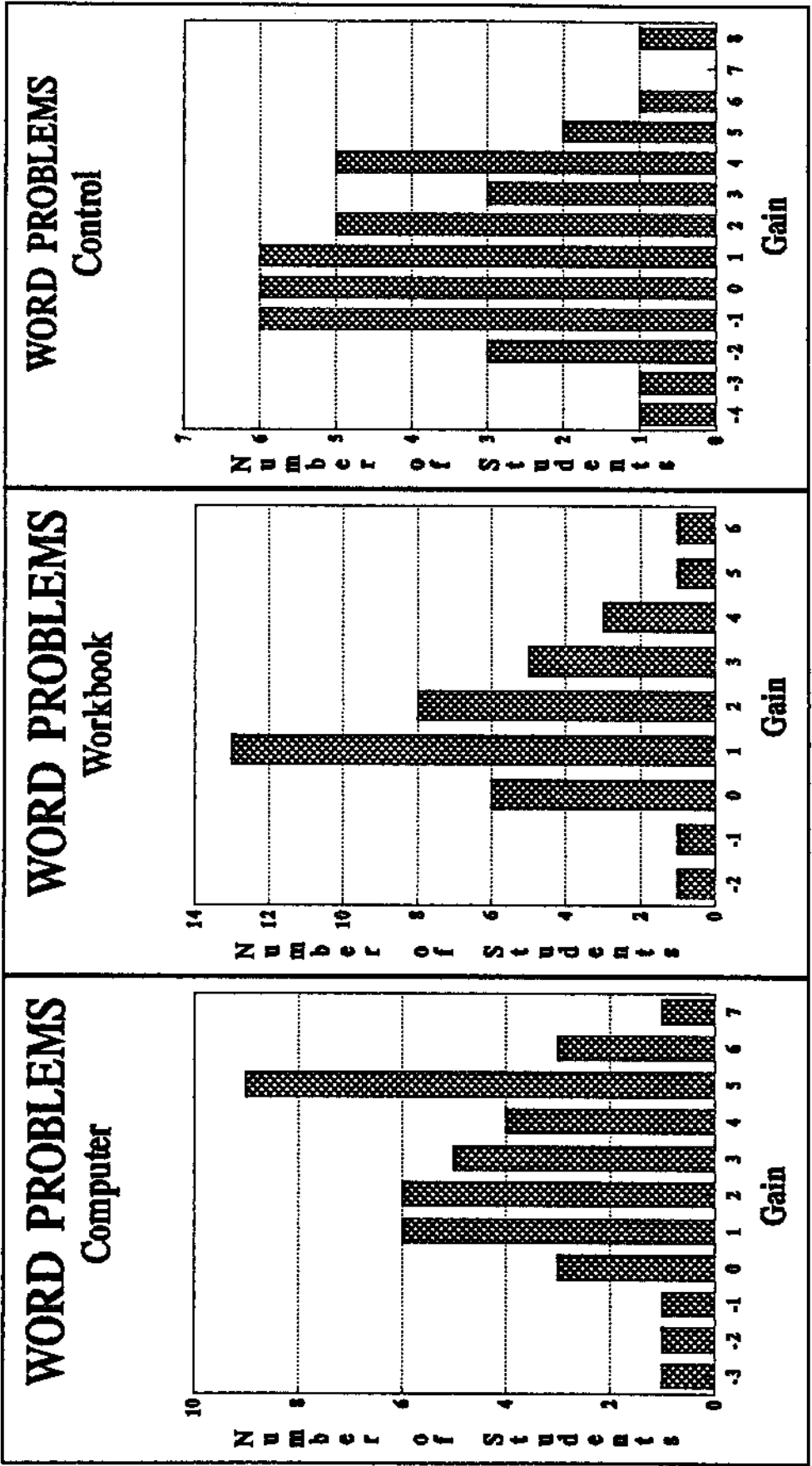
GRAPH 45 - GAINS BY TREATMENT



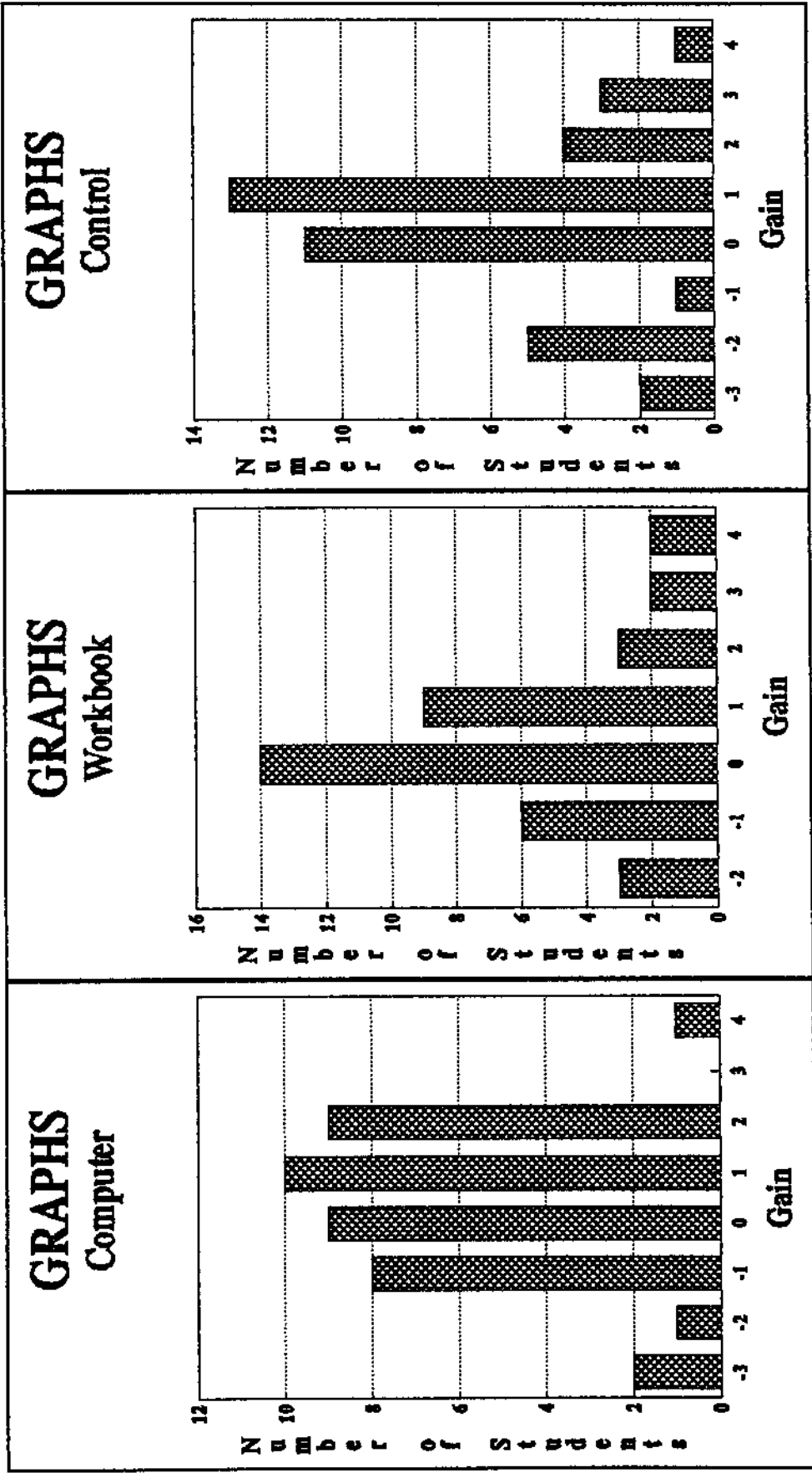
GRAPH 46: GAINS BY TREATMENT



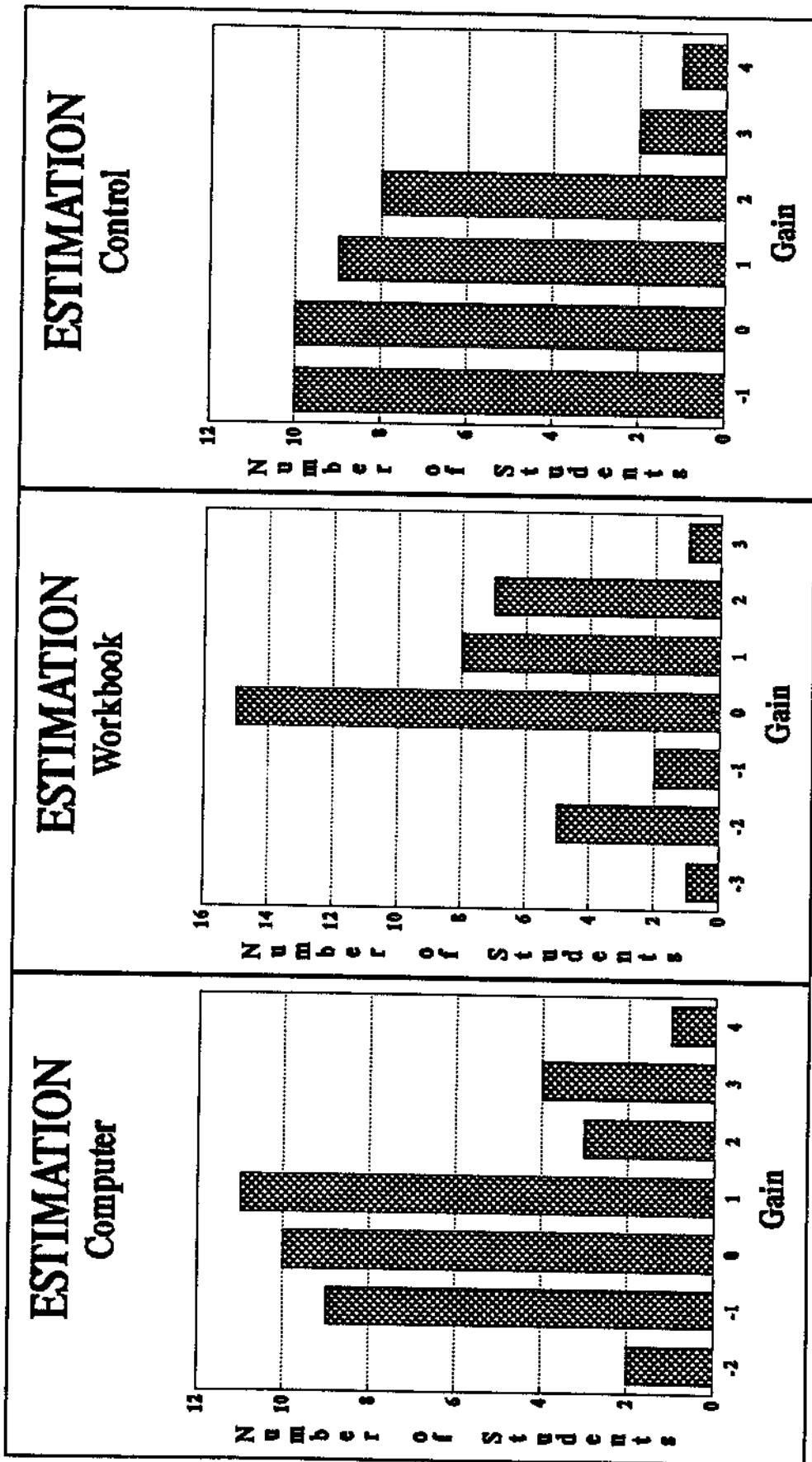
GRAPH 47 - GAINS BY TREATMENT



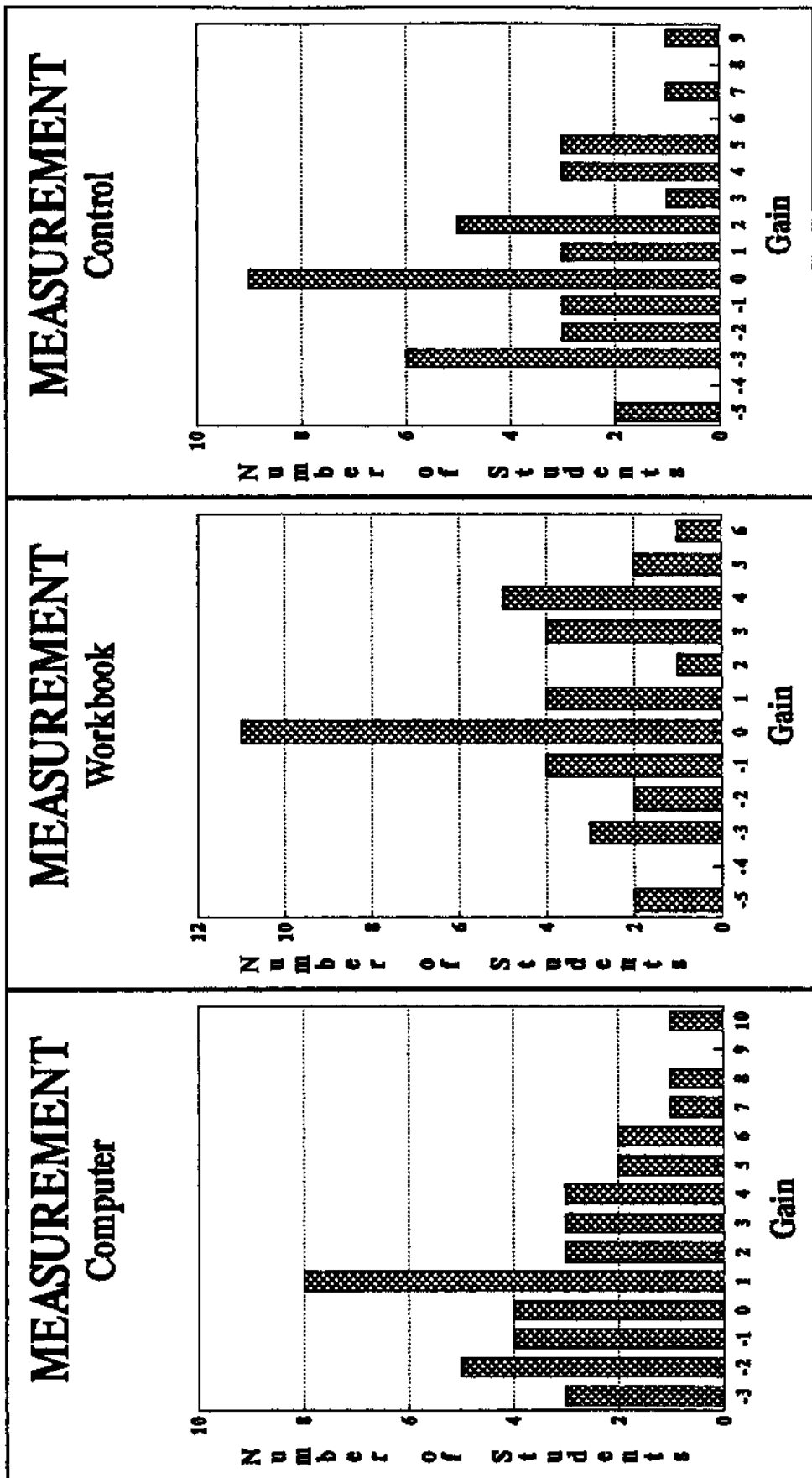
GRAPH 48 - GAINS BY TREATMENT



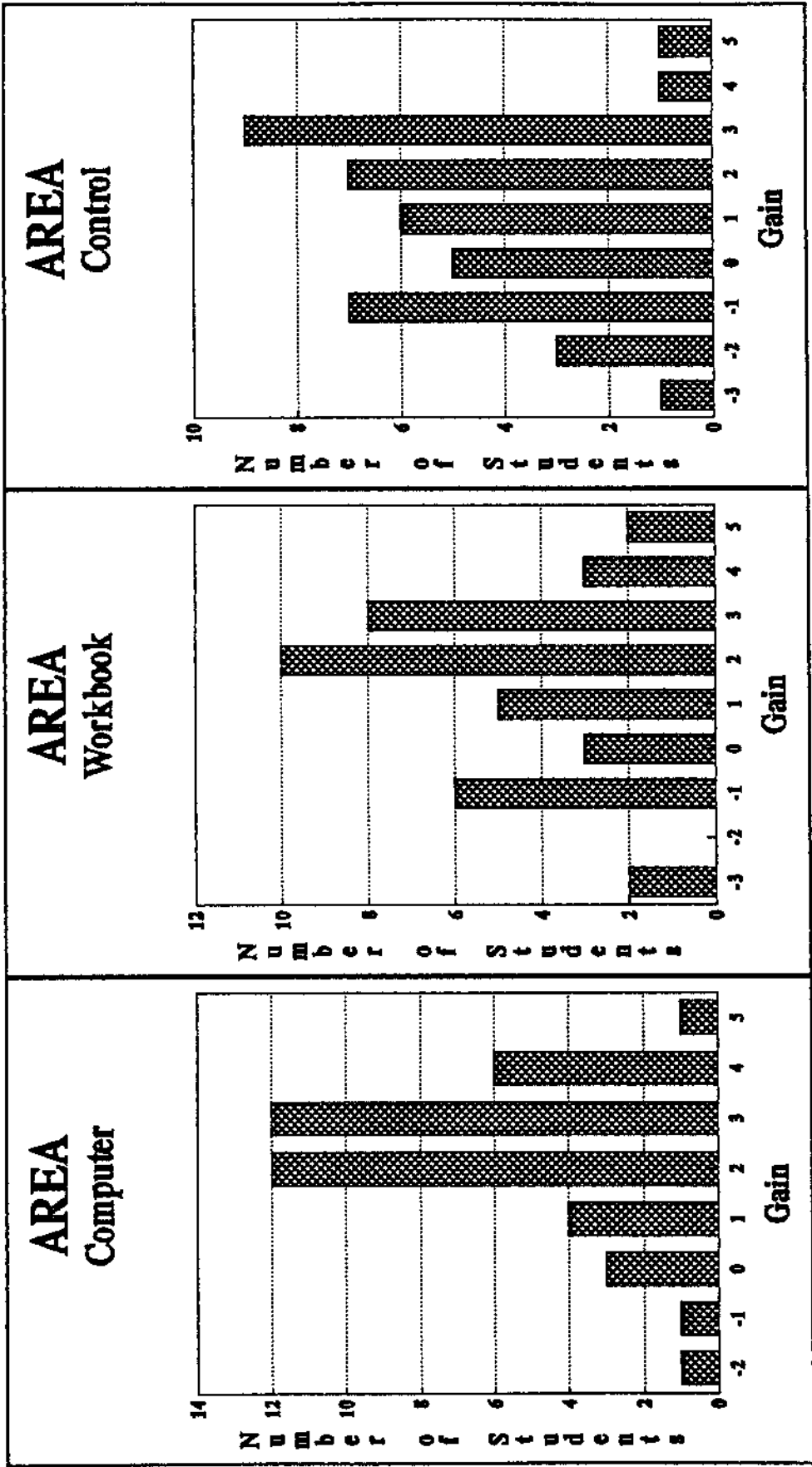
GRAPH 49 - GAINS BY TREATMENT



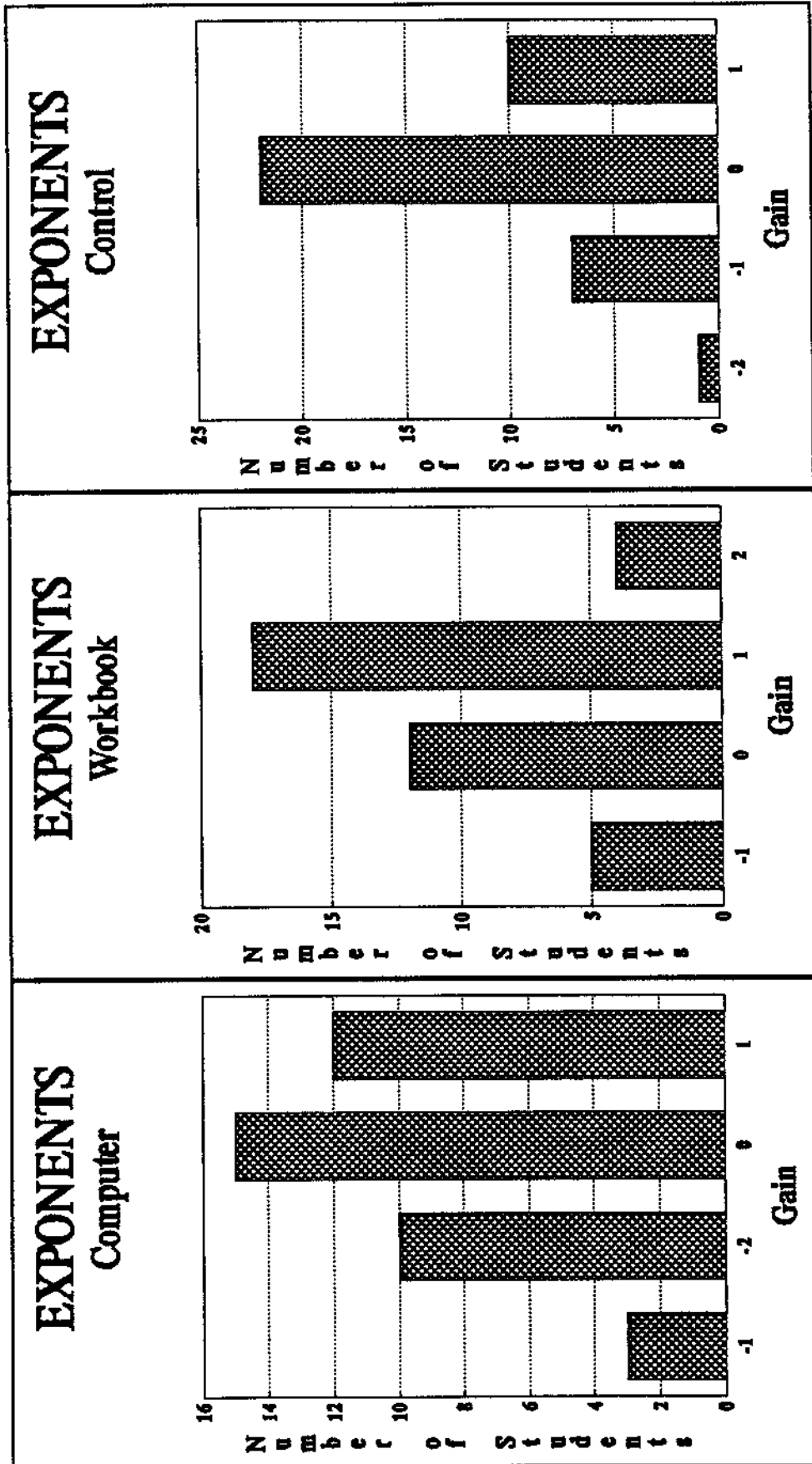
GRAPH 50 - GAINS BY TREATMENT



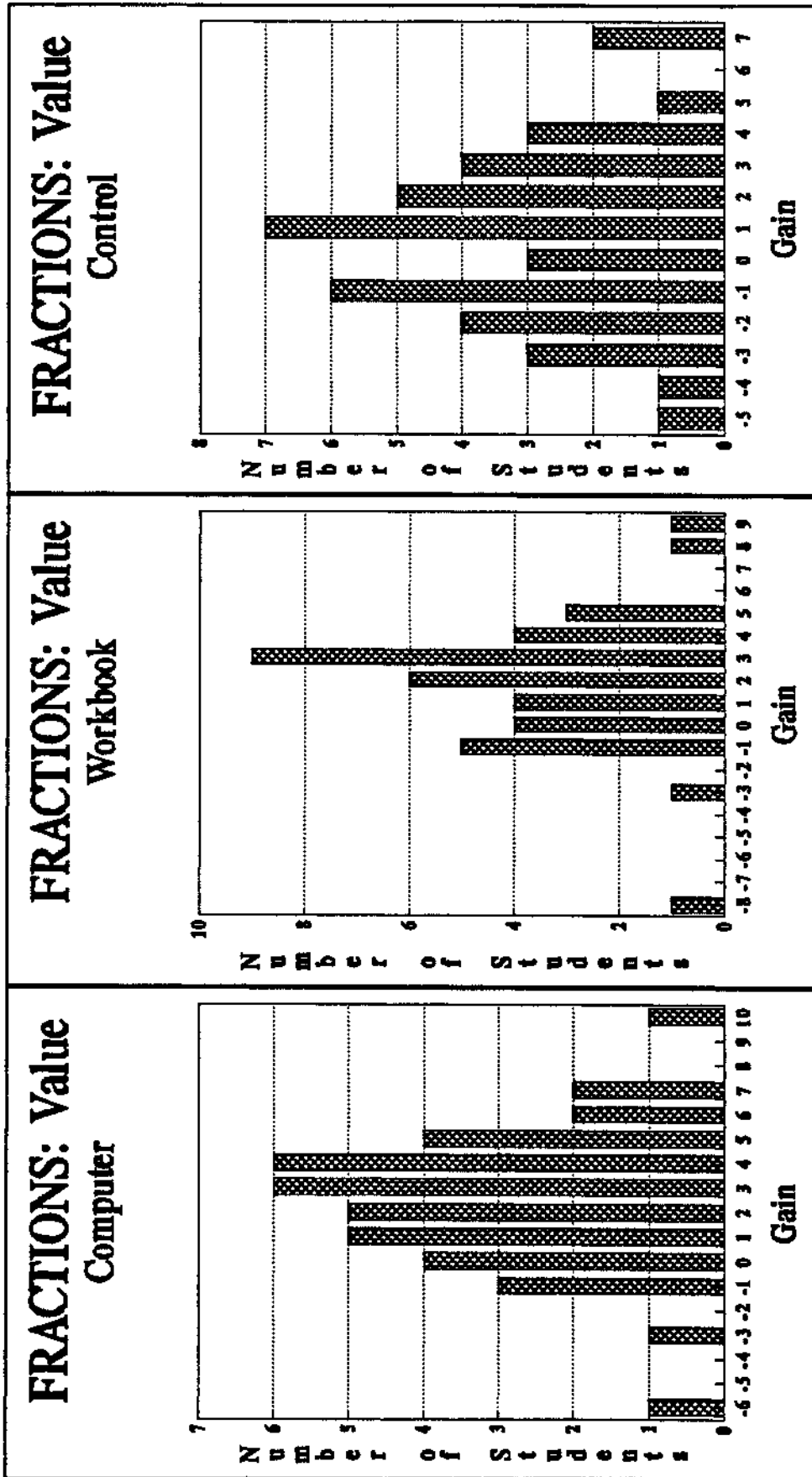
GRAPH 51 - GAINS BY TREATMENT



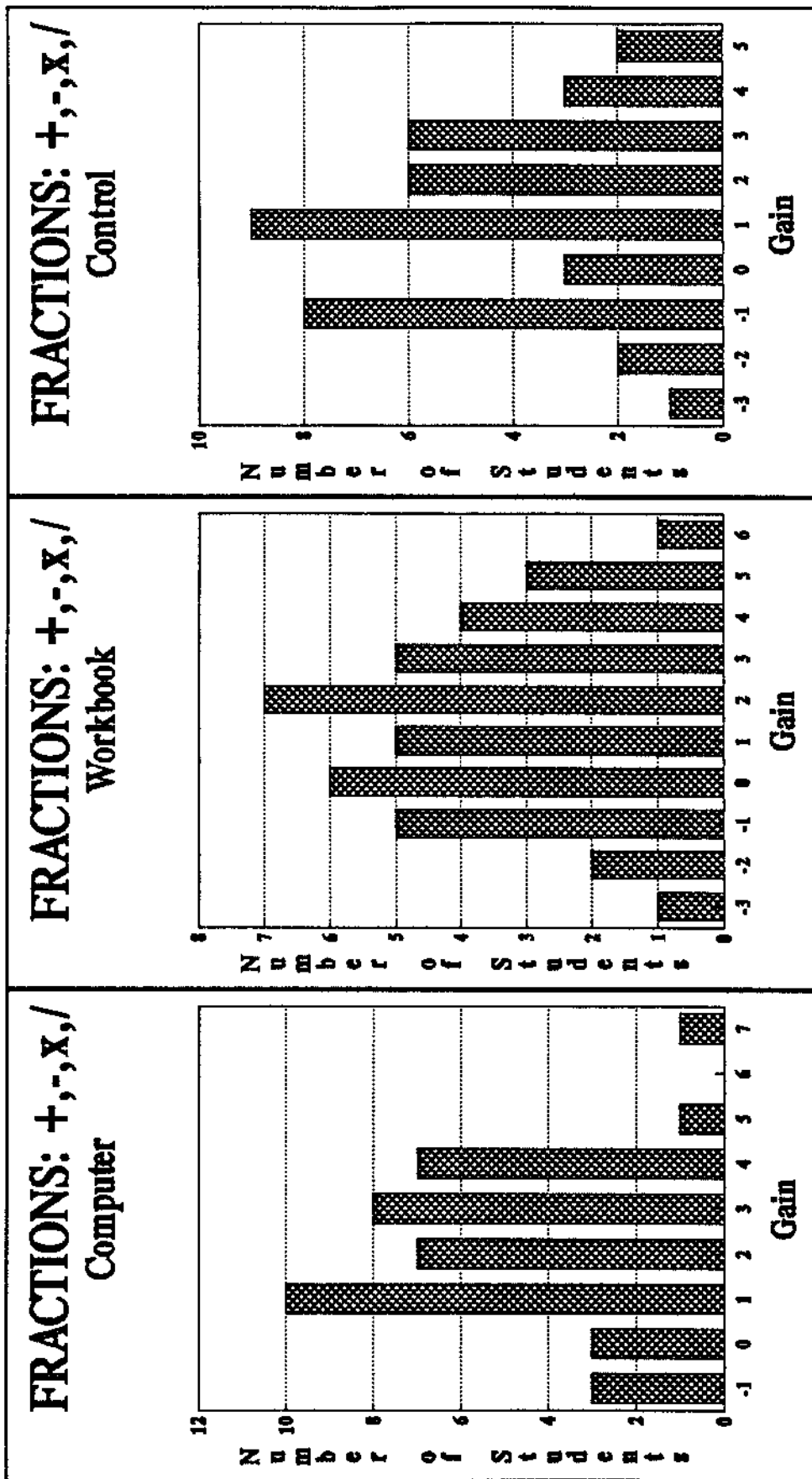
GRAPH 52 - GAINS BY TREATMENT



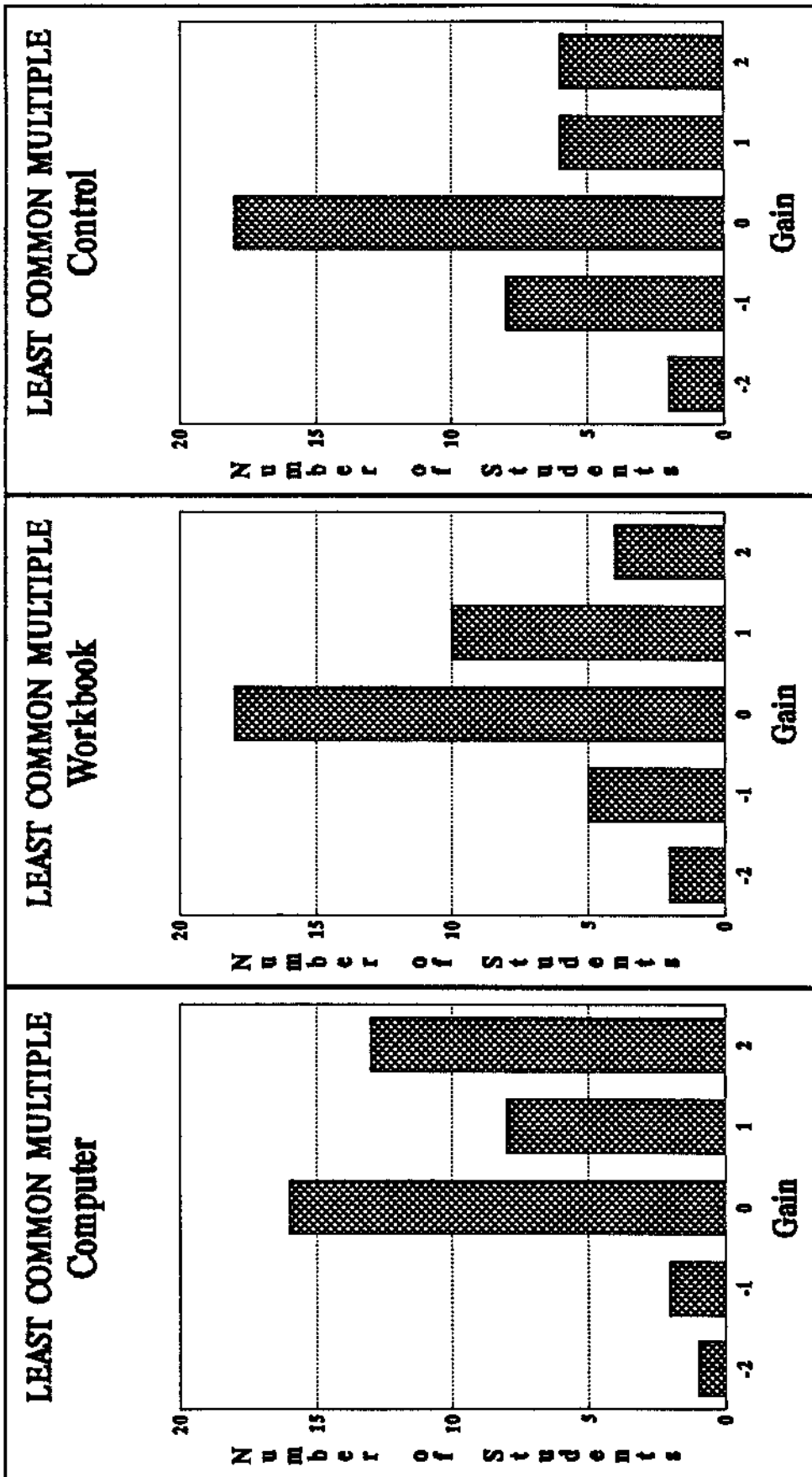
GRAPH 53 - GAINS BY TREATMENT



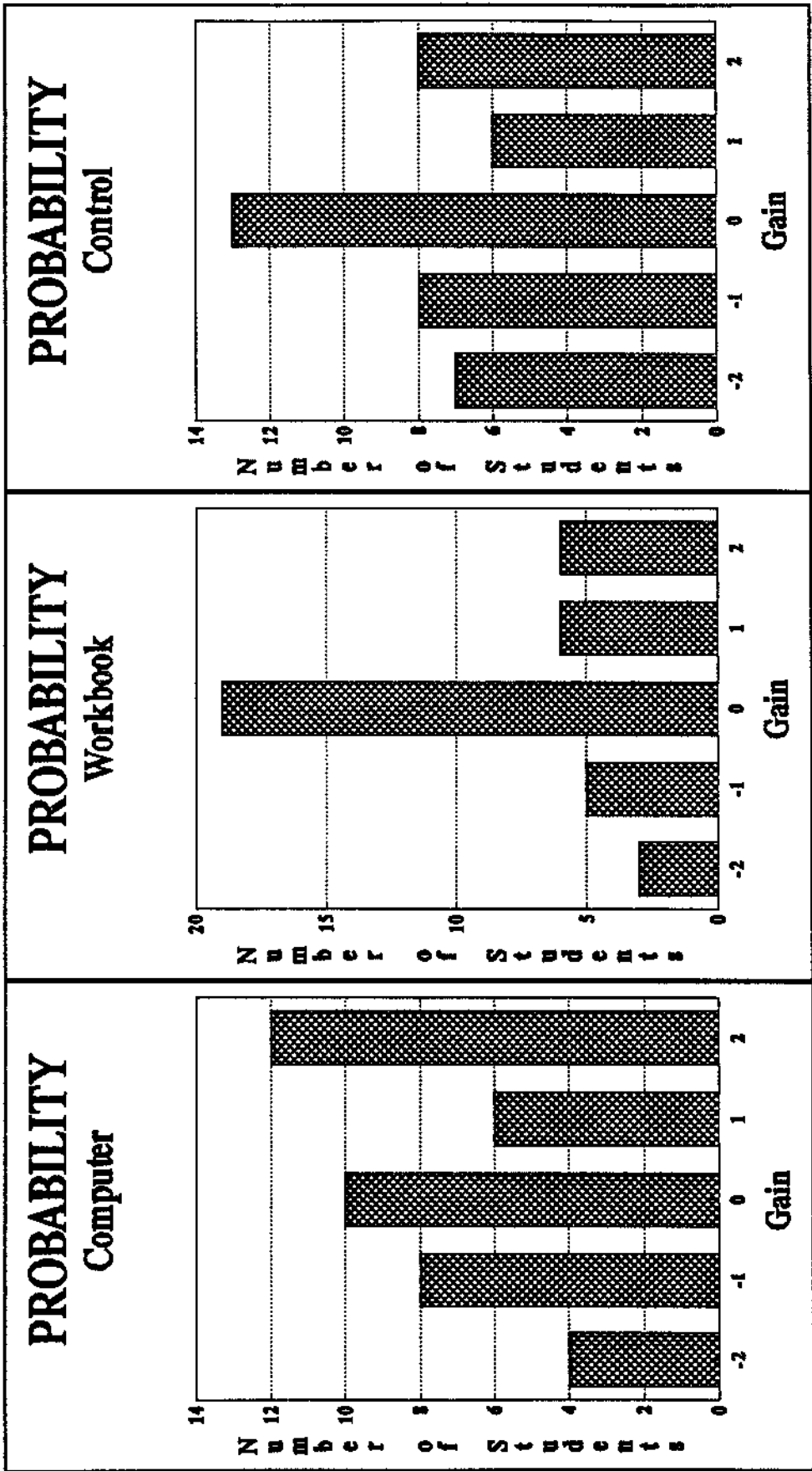
GRAPH 54 - GAINS BY TREATMENT



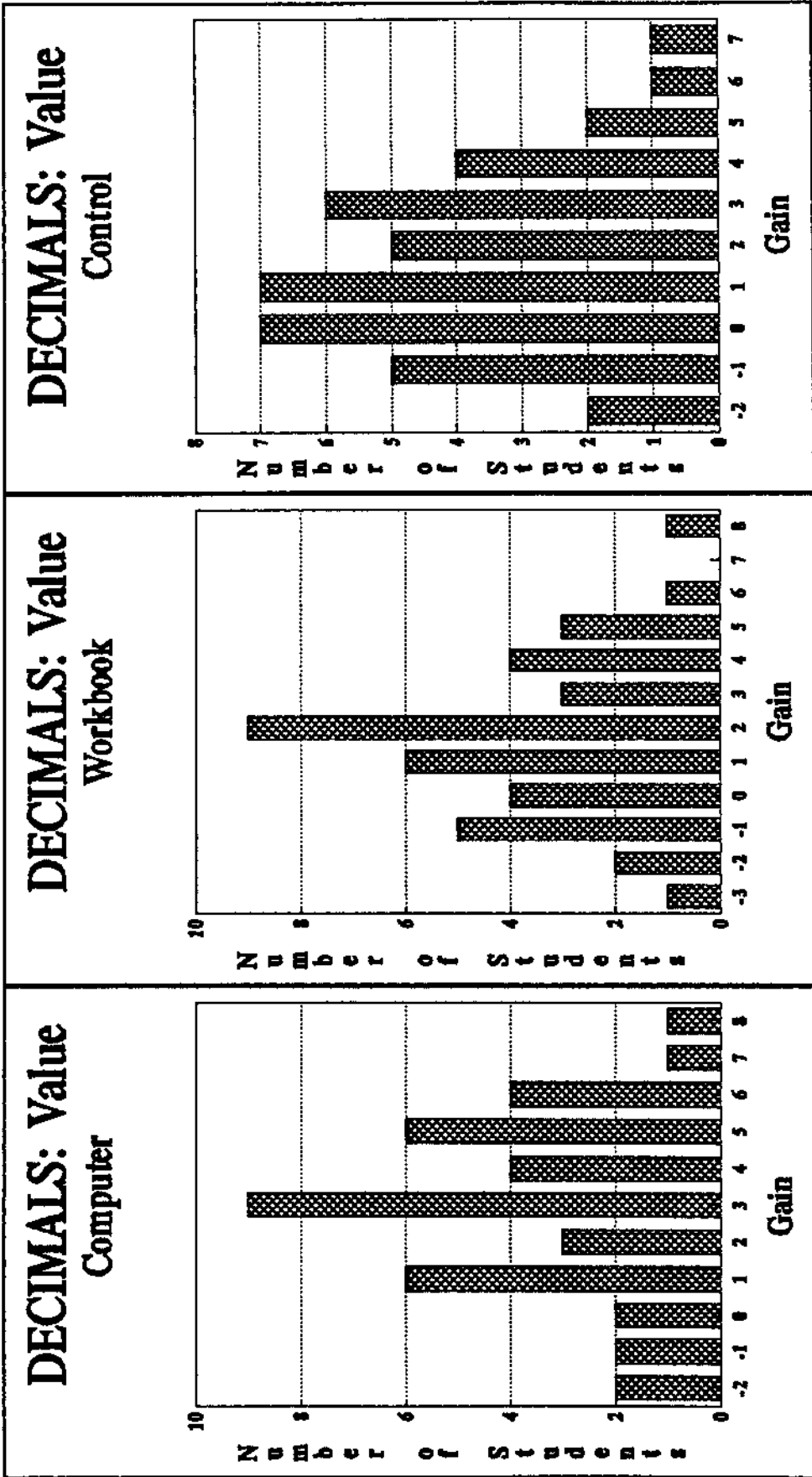
GRAPH 55 - GAINS BY TREATMENT



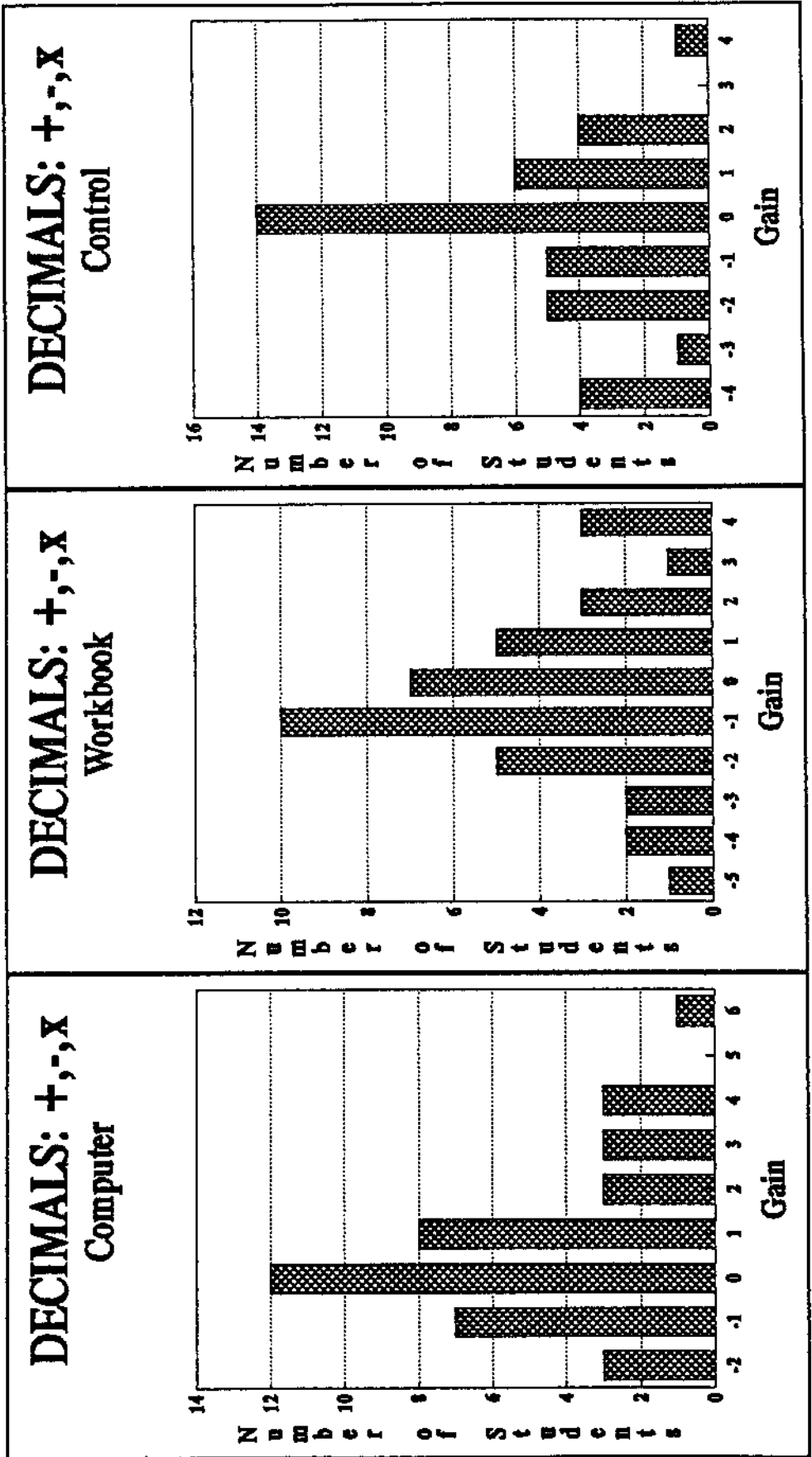
GRAPH 56 - GAINS BY TREATMENT



GRAPH 57 - GAINS BY TREATMENT



GRAPH 58 - GAINS BY TREATMENT



GRAPH 59 - GAINS BY TREATMENT

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