DOCUMENT RESUME

ED 423 869	IR 019 090
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TITLE	Computer Assisted Automatization of Multiplication Facts Reduces Mathematics Anxiety in Elementary School Children.
PUB DATE	1998-02-00
NOTE	10p.; In: Proceedings of Selected Research and Development Presentations at the National Convention of the Association for Educational Communications and Technology (AECT) Sponsored by the Research and Theory Division(20th, St. Louis, MO, February 18-22, 1998); see IR 019 040.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Academic Achievement; Automation; *Computer Assisted Instruction; Courseware; Curriculum Development; *Elementary School Mathematics; Elementary School Students; Grade 4; Instructional Effectiveness; Intermediate Grades; Mathematics Achievement; *Mathematics Anxiety; *Mathematics Instruction; *Mathematics Skills; *Multiplication; Sex Differences; Skill Development; Student Attitudes
IDENTIFIERS	*Automaticity Training; Mathematics Anxiety Rating Scale

ABSTRACT

Fourth grade elementary school children exhibiting high and low mathematics anxiety were trained on multiplication facts using the Math Builder Program, a computer program designed to bring their performance to the automaticity level. Mathematics anxiety, measured by the Mathematics Anxiety Rating Scale--Elementary version (MARS-E), was assessed before and after the students demonstrated automaticity level performance on the multiplication facts. Results showed that all of the students automatized the multiplication facts using computer training. Students in the high anxiety group averaged the greatest improvement in performance and were indistinguishable from the low anxiety group by the end of the automaticity training. The high anxiety girls, but not the high anxiety boys, significantly reduced their mathematics anxiety ratings. No significant change in mean anxiety ratings were detected for students in either of the low anxiety or the control groups. Results indicate that both high and low anxiety boys and girls achieved automaticity level performance of multiplication facts using computer assisted training, and training of multiplication facts to the automaticity level resulted in significant reductions of mathematics anxiety ratings. Results support the position that mathematics anxiety may result from a failure to learn or inadequate preparation in the mastery of fundamental skills. Implications of these findings for mathematics instruction and curricula development are discussed. (Contains 32 references.) (Author/AEF)

Computer Assisted Automatization of Multiplication Facts Reduces Mathematics Anxiety in Elementary School Children

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Abstract

Fourth grade elementary school children exhibiting High and Low mathematics anxiety were trained on multiplication facts using a computer program designed to bring their performance to the automaticity level. Mathematics anxiety, measured by the Mathematics Anxiety Rating Scale - Elementary version (MARS-E), was assessed before and after the students demonstrated automaticity level performance on the multiplication facts. Results showed that all of the students automatized the multiplication facts using computer training. Students in the High Anxiety group averaged the greatest improvement in performance, and were indistinguishable from the performance of the Low Anxiety group by the end of the automaticity training. The High Anxiety girls, but not the High Anxiety boys significantly reduced their mathematics anxiety ratings. No significant change in mean anxiety ratings were detected for students in either of the Low Anxiety groups or the Control groups. Results of the experiment indicate that both High and Low Anxiety boys and girls achieved automaticity level performance of multiplication facts using CAI training, and training of multiplication facts to the automaticity level resulted in significant reductions of mathematics anxiety ratings. These results provide support for the position that mathematics anxiety may result from a failure to learn or inadequate preparation in the mastery of fundamental skills. Implications of these findings for mathematics instruction and curricula development, in light of the NCTM Curriculum standards are discussed.

Mathematics anxiety has been shown to be a substantial problem for many students in the United States, Canada, Great Britain, Belgium, and other parts of the world (Lewis, Hitch, & Walker, 1994; Nimier, 1993). Studies have shown that a disproportionately greater percentage of females, compared to males, exhibit mathematics anxiety characteristics, and that mathematics anxiety may be responsible for detrimental and narrowing influences on the vocational and career choices of both men and women (Schneider & Nevid, 1993). Mathematics anxiety has been a significant problem for schools. While children do not begin their education with mathematics anxiety, many of them leave the educational system with it (Reyes, 1984). Despite the variety of views and models which have been proposed to explain mathematics anxiety (e.g. Dreger & Aiken, 1957; Dutton, 1954; Mandler & Sarason, 1952)., research has been less productive in identifying the causal factors which surround it (Hembree, 1988; 1990).

Consideration of the relationship between instruction and mathematics anxiety is especially timely considering the recently proposed NCTM Curriculm Standards (1989), which seek to greatly reduce the role of drills and rote mastery tasks in favor of making mathematics 'meaningful' by emphasizing the conceptual and contextual aspects of mathematics education. For some authors (Bloom, 1986; Carnine, Jones, and Dixon, 1994; Resnick & Ford, 1981), students' development of negative attitudes and frustration toward mathematics may result from the failure of schools to promote the learning of fundamental mathematics skills to mastery levels. The NCTM proposal has not been uniformly endorsed as the most suitable approach to mathematics reform (Carnine, Jones, and Dixon, 1994). Indeed, the controversy surrounding drill and practice has waged unresolved for quite some time (e.g. Bloom, 1986; Bryan & Harter, 1899; Carnine, Jones, and Dixon, 1994; Resnick & Ford, 1981; Reeve, 1944). Some authors have suggested that the dilemma surrounding student mathematics competencies may have been inherited as a by-product of the math revolution of the 1960s which de-emphasized drill and practice (Resnick & Ford, 1981), while others (Carnine, Jones, and Dixon, 1994), have argued that the goals and objectives proposed in the NCTM curriculum standards (1989) are virtually the same as those endorsed during the mathematics revolution of the 1960's.

The importance of drill and practice and its relationship to the acquisition of expert performance has been a topic of considerable interest (Salisbury, 1990; Salisbury & Klein, 1988). At the beginning of the 19th century, Bryan and Harter (1899) reported that the automatization of knowledge brought about by repetitive practice is instrumental, not only in the acquisition and refinement of new skills for novice learners, but is the foundation for the mastery level performance shown by experts. The role of the school system was seen as providing the instructional setting and opportunities for students to develop subject matter expertise through mastery of it's details. Bloom (1986), however, notes that children come to school poorly prepared to meet the challenges of learning, and that school systems, in general, are poorly equipped to be even less than moderately successful in developing mastery level subject performance among it's students. Thus, given the current de-emphasis on drill and practice activities in public school mathematics education, it is reasonable to anticipate that an eventual outgrowth of this failure to provide adequate essential training in basic mathematics skills would be manifested in the form of mathematics anxiety. Mathematics anxiety, therefore is viewed as resulting from a basic lack of knowledge, rather than the result of a pre-existing anxiety disposition, as has been suggested by others (e.g. Mandler & Sarason, 1952; Sarason, 1980).

The use of computer assisted instruction (CAI) offers an excellent vehicle for the assessment of the impact of mathematics drill and practice activities in elementary school children and it's relationship to mathematics anxiety. CAI technology could hold a great deal of promise for providing mathematics instruction to students who suffer from mathematics anxiety (Harris and Harris, 1987). In addition to offering individualization and flexibility, CAI based instruction is impartial, reinforcing, appeals to student interest, and also offers a sense of privacy for students who are anxious or self-conscious about their performance.

A number of recent investigations have examined the role of automaticity in learning by evaluating the performance characteristics of students trained on a particular task or skill to a level defined as 'automatic.' For example, Hasselbring, Goin, and Bransford, (1987; 1988) using computer based automaticity training, found that learning disabled children were able to master addition facts to the same levels as non-learning disabled control children who were given regular classroom instruction alone. Similarly, students with 'mild mental handicaps' benefited, significantly from automaticity training of addition and subtraction facts using a computer assisted 'drill-and-practice' instructional form (Lin, Podell and Rein, 1994; Podell and Lin, 1992). Other studies have examined the pivotal role played by automatization of performance in areas such as spelling (Ormrod & Lounge, 1990), and reading (Nicolson & Fawcett, 1990).

This study examined the relationship between 4th grade students' mathematics anxiety before and after automatization of multiplication facts, using a CAI drill and practice format. It was expected that students exhibiting high mathematics anxiety, but not low anxiety, would significantly reduce their mathematics anxiety ratings following CAI training of multiplication facts to the automaticity level. Further, it was predicted that high mathematics anxiety students would require significantly more trials to achieve the automatization of multiplication facts than students exhibiting low mathematics anxiety.

Subjects

The subject pool consisted of the total number of 4th grade students enrolled in a single public elementary school located in the Pacific Northwest. Fourth grade students were selected for the experiment because pilot research showed that these students were still in the initial stages of learning multiplication facts, and far from achieving automaticity. Some students did not participate in the study due to parental preference, and the data for other students was not included because the information was incomplete. A grand total of 63 students (81%) completed the experiment. There were 33 boys (52%) and 30 girls (48%). The individual student ages were evenly distributed across classrooms. The average age for boys was 10 years - 1 month, and for girls, the average age was 10 years - 0 months. Students receiving support through remedial services programs were not included in the experiment to further control the characteristics of the population sample.

Instrumentation

The primary instruments utilized in the investigation included the Math Builder Program© (Wittman, 1994), and the Mathematics Anxiety Rating Scale-Elementary School Level (MARS-E), (Suinn, Taylor, & Edwards, 1988). The Math Builder Program© is a CAI program developed by the first author using the Hypercard©

authoring system and is designed to provide drill and practice in basic mathematics facts. The program is considered 'user-friendly' because individual students are capable of operating the program following only brief initial instruction in its use, and distant supervision thereafter. Detailed information concerning the Math Builder Program as well as instructions for operation are available from the author (Wittman, 1996). The MARS-E (Suinn, Taylor, & Edwards, 1988) is a 26 item rating scale designed to measure the mathematics anxiety construct in 4th, 5th, and 6th grade elementary school children. The MARS-E was normed on 1,119 elementary school children randomly selected from 6 different school districts across the State of Colorado. Reliability estimates for the MARS-E, using the Cronbach's alpha statistic, was found to be .88. Construct validation data indicates that the MARS-E correlated significantly (-.31) with the Stanford Achievement Test, Mathematics Test, with component correlations for individual math skills (ie. applications, computations, concepts) ranging from -.26 to -.29. The MARS-E, and the remainder of the family of MARS tests (i.e. MARS, MARS-A) are considered the field standards in the assessment of mathematics anxiety.

Procedure

Two experimenters were available to work with the students throughout the spring term of the school year and terminating when the individual students either met the designated performance criterion, or the last week of the school year arrived. Individual students and teachers were not informed about the specific purpose of the investigation until it's conclusion. A group administration of the MARS-E was conducted with the students during regular classroom hours. Following a brief introduction each student was given a MARS-E protocol. The actual administration of the MARS-E took approximately 20 minutes for each individual classroom.

Following the pre-test, a total of twenty-four students were randomly selected from the upper (n = 12) and lower (n = 12) thirds of the mathematics anxiety distribution, forming 2 experimental groups: High Mathematics Anxiety, Low Mathematics Anxiety. Each of the two groups was subdivided evenly with respect to gender (6 male, 6 female) as well as mathematics aptitude based on their pre-existing 4th grade Metropolitan Achievement Test (MAT) results. An additional 12 students (6 male, 6 female) were randomly selected from the remaining pool of subjects to serve as a Control group for possible changes in MARS-E ratings resulting simply from the passage of time. Students in the Control group did not participate in the automaticity-training portion of the experiment. Any student whose overall MAT mathematics aptitude score was found to be in excess of 1.0 standard deviation above or below the mean for their particular group was dropped from the study and a different subject was selected from the pool of remaining student candidates.

Day 1

On Day 1 of CAI training, students were introduced to the Math Builder Program individually by the experimenter to ensure a thorough understanding of the program and it's operation. The experimenters were blind to each subject's mathematics anxiety condition throughout the course of CAI training and testing, as well as during the post-test administration of the MARS-E. For the purpose of the present investigation students worked exclusively on the multiplication component of the Math Builder Program.

Level-I Problems

After familiarization had been completed, each student was allowed the opportunity to complete 3 Level-I Multiplication Problems for practice. Thereafter, each student was given daily practice on Level-I problems until a criterion score of 29/30 correct responses for each problem had been achieved on two consecutive daily trials. Level-I problems consisted of 30 multiplication facts were selected from the standard matrix of multiplication facts. Selection was narrowed to include only one fact associated with any fact-pair (e.g., only one form of the problem pair 3 x 2, or 2 x 3, selected at random was used), the limited use of fact-twins (e.g., 5 x 5, or 6 x 6; only 2 of the 10 available twins were selected and used in the experiment), and the elimination of 0 and 1 number facts from consideration (e.g., 3 x 0, or 4 x 1). Information concerning the specific multiplication facts used in the experiment is detailed in Wittman (1996). The same multiplication facts were used throughout the entire course of the experiment, however, the order of problem presentation was randomized prior to each session. Information concerning the number of correct answers was recorded from the student's score card at the end of each session and entered into a spreadsheet. Once a student met the criterion score of 29/30 on the Level-I problems for 2 consecutive sessions, the student was advanced to the Level-II problems at the next scheduled training session. The requirement of 2 consecutive near-perfect sessions for the Level-I problems was designed to meet the criterion established by Hasselbring, Goin, and Bransford (1988), that students have an established declarative knowledge base for the recall of mathematics facts from memory. Students who were observed using an obvious procedural strategy during the Level-I phase of the Math Builder Program were gently reminded to answer on the basis of recall, and to 'guess if necessary,' if uncertain about the answer to a problem. The criterion of 29/30 correct was adopted for the experiment instead of the more rigorous 30/30 because pilot data indicated that most of the students in the tryout made at least one 'careless error' during any given individual session.

Level-II Problems

The Level-II component of the Math Builder Program was designed to bring the level of student performance of basic multiplication facts to a level defined as automatic. According to Logan (1985) simply knowing the answer to a problem is different than automatization of the response. In the case of automaticity, the qualifying criterion refers to a specific 'effortless' property of performance. In research practice, the parameters concerning what constitutes the automatization of mathematics facts have been variable, ranging from one or three seconds per problem, (Wiebe, 1988; Hasselbring, et al, 1987; 1988). Initial test trials using the Math Builder Program was largely consistent with these parameters. Pilot testing showed that the 3-second interval comfortably reflected the student's uninterrupted movement of the mouse to the response button immediately after the initial presentation of the multiplication fact on the computer. Any attempt by students to problem-solve a multiplication fact using a strategy other than memory retrieval (e.g. counting, adding on) resulted in reaction times that were always 4 seconds or considerably longer. In practice, the students continually worked harder to earn increasingly faster reaction times, despite the 3 second criterion, and the majority of the students were responding to multiplication facts within one or two seconds per problem.

The dependent variables to assess the development of automaticity consisted of assessing mean changes in student reaction times to individual multiplication facts across sessions, as well as a daily assessment of the overall number of responses which met the criterion set for automaticity across problems. In order to meet this latter objective, students' scores for each daily session were converted to automaticity quotients (Wittman, 1996), then transformed to logarithms. The formula for the automaticity quotient is given by the following:

(a/non-a) x 100 = aq

where a = the number of correct responses in a given daily session which occurred in 3 seconds or less, and non-a = the number of responses which did not meet the 3 seconds criterion or were simply incorrect.

Thus, for a fixed number of 30 daily problems n = 30

for an outcome < 50% automaticity	(5/25) x 100 = 20	LogAQ (20) = 1.30
for an outcome = 50% automaticity	(15/15) x 100 = 100	LogAQ (100) = 2.00
for an outcome > 50% automaticity	(25/5) x 100 = 500	LogAQ (500) = 2.69

The LogAQ characterizes the development of automaticity as a monotonically increasing linear relationship between the number of successfully automatized versus non-automatized problems found in a given daily session. The LogAQ transformation compacts extreme scores into a more uniform distribution to better meet the requirements for statistical tests (Howell, 1993).

For the Level-II sessions, students were seated individually before the computer and performed under conditions identical to those used for the Level-I condition. The Level-II program began with an initial set of instructions emphasizing the importance of accuracy and speed of response. Students were reminded that the goal of Level-II would be to maintain accuracy while responding with increasingly faster reaction times to each problem presented. The experimenter uniformly encouraged students to "beat your best time" throughout the Level-II sessions. Level-II problems consisted of a randomized list of the same multiplication facts used in the Level-I series. The problems, and the corresponding response buttons were randomized across presentations to ensure that the students' learning reflected genuine recall of the mathematics facts, and not memorization of the pattern of answers. As noted in the description of the Level-II problems, students received visual feedback about their reaction time for each problem they solved correctly. Criterion for automaticity at Level-II, evidenced by student reaction times of 3 seconds or less to each of the 30 individual multiplication problems for 3 separate session presentations, was recorded and entered into a spreadsheet at the end of the day. Students practiced all 30 of the multiplication facts until the criterion for each of the 30 multiplication facts had been met.

MARS-E Post-Test

Once each of the 24 students achieved criterion performance on the Level-II multiplication facts, the MARS-E was readministered. The students who did not participate in the CAI portion of the experiment were simply readministered the MARS-E in their classrooms.

Results

The results of the experiment provided confirmatory evidence for the primary research hypotheses. The students achieved automaticity level performance as a result of CAI training, which, in turn, resulted in significant reductions in mathematics anxiety ratings for students in the High, but not Low Mathematics anxiety groups.

Analysis of Demographic Information

Independent analyses of the subject population by MARS-E Pre-Test and by (CTBS) Mathematics Achievement failed to identify any significant differences between groups as a function of gender, classroom placement, or the interaction between these variables (all p's > .05). Detailed information concerning these results is available in Wittman (1996).

Analysis of pre-treatment variables

MARS-E pre-training scores. A exploratory 3 x 2 ANOVA with groups (High Anxiety, Low Anxiety, Controls) and gender (Boys, Girls) for the MARS-E pretest variable demonstrated a significant main effect of anxiety condition ($F\ (2, 27) = 44.429$, $MSE = 89.89$. $p < .0001$). Analysis of the main effect of anxiety using the Newman-Keuls statistic demonstrated significant differences between each of the anxiety conditions and the control groups (all p's $< .05$), verifying that the deliberate selection procedure of the 2 anxiety groups and the random selection of control subjects resulted in clear differentiation on the mathematics anxiety dimension. Comparison of these 3 groups to the normative data provided by Suinn, et al. (1988), demonstrated that the mean ratings for students in the High Anxiety condition corresponded to the normative group scoring at the 95th %tile (+1.5 SD), the students in the Low Anxiety condition were found to be at or below the 10th %tile of Suinn's distribution (-1.5 SD), and the scores of the students who were selected at random to occupy the Control condition clustered closely around the 50th %tile. A similar 3 x 2 ANOVA calculated to examine the relationship between mathematics achievement variable and the MARS-E scores, demonstrated a significant main effect of anxiety condition ($F\ (2, 27) = 8.05$) $p < .001$). The main effect of gender ($F\ (1, 27) = .018$, ns) and the interaction between gender and anxiety condition ($F\ (2, 27) = .064$, ns), however, did not prove statistically significant. A Newman-Keuls analysis of the main effect of anxiety group demonstrated that the High Anxiety student group manifested significantly lower CTBS total mathematics achievement scores than students in either the control group or in the Low Anxiety condition (p's $< .05$). Students in the control group, did not differ significantly in math achievement, compared to the students in the Low Anxiety condition.

Differential performance of the anxiety groups

Analyses of student performance across the course of the experiment showed that students in the High Anxiety condition improved their knowledge and proficiency in solving basic multiplication facts, significantly, as a function of drill and practice. While the High Anxiety students' performance was initially inferior compared to their Low Anxiety counterparts, beginning with the Level-I problems, the differences were greatly reduced across the Level-II sessions, and eventually eliminated. The performance of the students in the Low Anxiety condition, while superior to the High Anxiety students on Level-I problems and across the course of the Level-II problem series, became quickly asymptotic, after which the High Anxiety students narrowed and eliminated the gap. These results are described in detail in Wittman (1996).

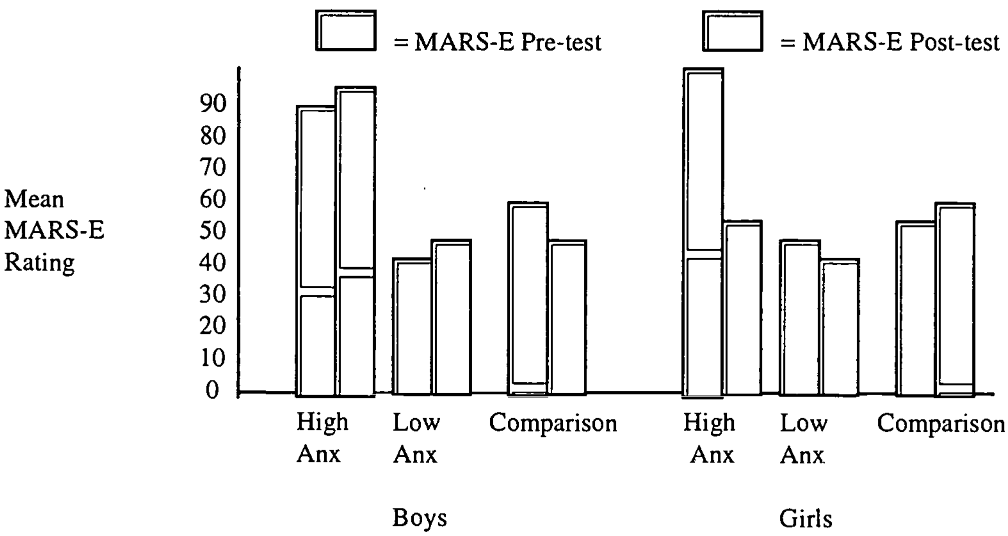
MARS-E Test Results

The results of the MARS-E pre and post test ratings were analyzed using a 2 x 3 x 2 split plot factorial ANOVA with gender (boys, girls), anxiety condition (High Anxiety, Low Anxiety, Comparison), test session (Pre-test, Post-test), and the interaction between these variables serving as factors. Results of this analysis revealed a significant main effect of anxiety condition ($F\ (2, 27) = 24.41$, $MSE = 245.08$, $p < .0001$), and the 3-way interaction between gender, anxiety condition, and test session (F (2, 27) = 3.64, MSE = 210.25 $p < .039$). Neither the main effect of gender, or any of the other interaction terms approached statistical significance (F's < 1).

Breakdown of the results of the main effect of anxiety condition using studentized range t-score statistic, and the MSE for subjects error term from the main analysis showed that, overall, the students in the High Anxiety group generated significantly higher overall MARS-E ratings than the students in the Low Anxiety group (M diff = 34.72, t (1, 27) = 7.27, SEM = 4.77, $p < .01$), and students in the Comparison Group (M diff = 24.43, t (1, 27) = 5.12, SEM = 4.77, $p < .01$). The Comparison Group's performance was intermediate in relation to the High and Low Anxiety groups and did not differ significantly from the Low Anxiety group, (M diff = 10.29, t (1, 27) = 2.15).

Results of the triple interaction (figure 1) demonstrated that the relationship between anxiety condition and pre-test versus post-test performance, primarily reflected a significant decrease in pre-post test MARS-E ratings for the girls in the High Anxiety group {F (1, 27) = 9.14, $p < .01$). None of the other comparisons within gender and anxiety conditions, across the pre versus post test intervals came close to reaching statistical significance (all p's > .05)}.

Figure 1. Graph of the gender x anxiety condition x pre/post-test MARS-E ratings: (H = High Anxiety, L = Low Anxiety, C = Comparison Group).



Comparisons for girls at the pre-test interval showed that High Anxiety girls reported significantly greater mathematics anxiety than the girls in either of the Low Anxiety or Control group conditions (p's < .05). The girls in the Control group, did not differ significantly from the girls in the Low Anxiety condition. At the post-test intervals, however, the High Anxiety girls reduced their mathematics anxiety ratings to a level which did not differ significantly from the control girls ($p < .05$). The ratings of the High Anxiety girls were significantly higher than the Low Anxiety girls ($p < .05$).

Similar analyses of the triple interaction for boys revealed significant differences between the anxiety and control conditions at the pre-test as well as at the post-test intervals. The nature of these results was explored using the studentized range statistic and the pooled between MSE terms drawn from the main analysis. At the pretest interval the results showed that the boys in the High Anxiety group reported significantly greater mathematics anxiety ratings than students in either the Low Anxiety group or the Control group, and the mathematics anxiety ratings for students in the Control group were intermediate in relation to the High Anxiety and the Low Anxiety groups. The same comparisons between anxiety conditions for the boys at the post-test intervals showed that the boys in the High Anxiety group continued to report significantly higher mathematics anxiety ratings than the boys in the Low Anxiety and the Control groups (p's < .01), however, the latter two groups no longer differed significantly from one and other.

Analysis of the triple interaction for boys and girls within each anxiety condition, across test sessions confirmed the results of previous analyses with respect to the performance of students in the High Anxiety conditions by showing that only the girls in the High Anxiety condition significantly lowered their MARS-E ratings between the pre-test and the post-test ($p < .05$). Similar comparisons examined for the remaining groups were not statistically significant (all p's $> .05$).

Discussion

The results of the experiment provided confirming evidence in support of the main research question; a reduction of mathematics anxiety was achieved among girls in the high anxiety condition presumably as a result of automatization of multiplication facts using the CAI program. Specifically, the girls in the High Anxiety condition evidenced a significant reduction in MARS-E ratings at the post-test, compared to their pre-test ratings. At the post-test, the High Anxiety girls' mathematics anxiety ratings were indistinguishable from a group of control girls who's performance was found to be within the average range, compared to Suinn, et al's (1988) MARS-E normative sample. Thus, a group of girls who initially reported clinically debilitating levels of mathematics anxiety, at the pre-test (ie. 95th %tile), subsequently changed their mathematics anxiety ratings to the 'average range' (50th %tile), as a result of the CAI intervention and automatization of multiplication facts.

While these results are encouraging, it is not entirely clear why the significant decrease in mathematics anxiety rating was confined purely to the girls in the High Anxiety group. Since the pattern of performance of the boys and girls in the High Anxiety group was statistically identical across virtually all of the experimental measures, it would seem reasonable to expect that parallel performance should have been obtained with respect to the mathematics anxiety variable, as well. Indeed, given the prevailing 'masculine attitude' toward male superiority in mathematics one would expect that boys would be more likely to understate, than overstate their mathematics anxiety ratings, resulting in a built-in degree of statistical regression of scores across the course of the experiment. Instead, however, the High Anxiety boys appeared to be quite willing to report their anxieties about mathematics and maintained this position from pre-test to post-test. A second and more parsimonious explanation for the differential results could reside in the very small number of boys making up the High Anxiety group who actually completed the experiment. The subject mortality rate of 50% is substantial. It would be difficult to draw further conclusions concerning the mathematics anxiety variable for these particular students with a subject pool of only 3 boys making up the High Anxiety condition.

Neither the students in the Low Anxiety or the Control groups demonstrated a significant reduction in mathematics anxiety ratings between the pre and post test intervals and this finding is not surprising. Since the average MARS-E ratings of the Low Anxiety group clustered around the 10th percentile of the normative distribution, any substantial improvements that they might have made in terms of MARS-E ratings would have easily been masked by 'floor effects.' Since students in the Control condition did not experience the CAI portion of the experiment, changes in mathematics ratings would not be expected. Perhaps of even greater importance, however, was the observation that none of the students showed increased mathematics anxiety ratings resulting from the CAI drill and practice sessions. Thus, the question concerning whether routine drill and practice activities might be somehow anxiety inducing, appears unlikely, viewed from the standpoint of the performance of the present 4th grade student group. The results of the experiment provided encouraging evidence to support additional efforts in the study of the relationship between anxiety variables and automaticity.

The results of the experiment hold important implications for elementary school mathematics instruction, particularly in light of the 1989 National Council of Teachers of Mathematics (NCTM), curriculum standards. In addition to the reduction of mathematics anxiety, other results of the experiment (Wittman, 1996) showed that student performance on multiplication facts was substantially improved using the Math Builder program. This improvement was observed regardless of whether individual students exhibited High or Low Anxiety levels. The controversy surrounding the best approach to mathematics instruction, (ie. drills versus conceptual) is beside the point. In order for students to make mathematics a skill to be used meaningfully for problem solving, students need to automatize the facts and routines to the degree that conceptual processing of information occurs independently of these basic processes. Students' whose mathematical problem-solving performance is hindered by the continual need to review facts and procedures will learn to view mathematics as an anxiety provoking experience. Providing students with the opportunity for sufficient drill and practice will empower them with the capacity to go beyond the basics; a process of drill and discovery.

The results of the experiment provide support for the position that mathematics anxiety does not necessarily exist as a personality characteristic predating and independent-of mathematics performance. Similar to Tobias (1985), our position suggests that mathematics anxiety develops as a logical reaction to insufficient learning of fundamental skills. Instructional programs, and especially CAI programs, which emphasize training student performance on basic number facts to the automatic level will provide students with the skills they need to become confident mathematicians.

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