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The Ohio State University

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LEARNING DISABILITIES AND MICROCOMPUTER COURSEWARE:  
A QUALITATIVE STUDY OF STUDENTS' AND TEACHERS' INTERACTIONS  
WITH INSTRUCTIONAL DIMENSIONS  

DISSERTATION  

Presented in Partial Fulfillment of the Requirements for  
the Degree Doctor of Philosophy in the Graduate  
School of The Ohio State University  

By  

Mary Delia Neuman, A.B., A.M.  

* * * * *  

The Ohio State University  
1986  

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Keith A. Hall  
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To my family

in appreciation for their constant love and support
during this and all the other adventures of my life:

Rita and Joseph Tye
Kathryn and Clarence Broderick
Rita Tye Backenstose
and, especially,
Michael
Many people were instrumental in the completion of this study, and their contributions are acknowledged with affection and gratitude:

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My committee--Keith Hall, Don Sanders, and Tim Heron--whose encouragement as well as their expertise made the research experience gratifying on a number of levels;
My peer reviewers and friends—Nancy Chism, Cathy Fitch, Mike Neuman, and Sallie Sherman—who made the resulting document stronger, clearer, and more useful;

And most of all my husband Michael Neuman—whose patience, humor, insights, and generosity of spirit throughout this adventure made its difficulties more endurable, its satisfactions more rewarding, and its completion truly a shared achievement.
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including the following instructional units for hearing
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Feelings: Keys to Values
Decisions! Decisions!
Coping with Conflicts
Shooting for Goals
Career Awareness Learning Activities, Levels 1 and 2

micro: A demonstration. Paper presented at the First
National Conference on the Use of Microcomputers in Special
Education, Hartford, CT. (ERIC Document Reproduction
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Evaluation report. Columbus, OH: The Ohio State
University, National Center for Research in Vocational
Education. (ERIC Document Reproduction Service No. ED 250
461)

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microcomputer courseware: A qualitative study of students'
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meeting of the American Educational Research Association,
Chicago.

Neuman, D. (1986, February). Learning disabilities and
microcomputer courseware: A qualitative study of students'
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fields of study

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CHAPTER I
INTRODUCTION

Special education, like all areas of education, has been inundated with microcomputers over the past several years. The technological advances and associated hype that have pushed the micro into the consciousnesses of regular educators across the country have marched it into the forefront of special educators' minds as well. As Blaschke (1985) reported, "By December 1983 approximately 60,000 microcomputers were used [throughout the country] primarily for special education. . . . This year, approximately 150,000" (p. 74) will be used in this way.

Accompanying this growth in the number of machines in special education settings is a parallel increase in the number of research publications, "tips-for-practitioners" articles, state and national conferences, local and regional workshops, and professional organizations devoted to the topic of technology in special education; even the popular press has focused attention on the promise that microelectronics holds for the student with special learning needs. Bailey and Raimondi (1984) offered a partial list of professional resources that includes seven
periodicals, six books, seven organizations, eight resource groups, three networks, and six state and federal projects concerned either solely or in part with the uses of technology to address special needs. Absent from this list are a number of other sources--conferences, books, special issues of journals, other funded projects--that also deal with the many issues in this field.

Publishing firms are beginning to respond to the situation by creating software specifically for this population. DLM, long a producer of other materials for special needs students, is the best known of the publishers of special education courseware. Newer, smaller companies--such as Hartley Courseware, Laureate Learning Systems, and MCE--are entering the field, while older, established general publishers--such as McGraw-Hill and Random House--also market special education courseware. Recently even IBM, the computer industry giant, established a focus in this area as part of its reorganization.

Perhaps most indicative of the growth of interest in technology (especially microcomputers) in special education are the activities of the Council for Exceptional Children--the major professional organization for special educators. Since 1981, the Council has devoted one entire issue of its research journal (Exceptional Children, October 1982) and two issues of its practitioners' journal
to the place of microcomputers in special education. It has been the sole sponsor of two national conferences on microcomputers (March 1983) and technology (January 1984) in special education and has joined with other agencies to provide a variety of other opportunities for professional development and information exchange. Most recently, with funding from the U. S. Department of Education, the Council was involved in two major national efforts: a research symposium (June 5-6, 1985) sponsored by the Council's Center for Special Education Technology Information Exchange and the First Special Education Software Center Conference (June 6-7, 1985)--a joint venture of the Council, LINC Resources, and the Special Education Software Center located at the Stanford Research Institute.

In many of these forums, a great deal of attention has been given to the potential of computers for serving the physically handicapped (e.g., as communication aids or devices for allowing environmental control) and the sensorially deprived (e.g., as mobility aids for the visually impaired and language-training devices for the deaf). While these uses are certainly significant, the potential of the computer for serving the instructional needs of the mildly handicapped--those learning disabled, speech impaired, mildly retarded, and educationally
disadvantaged children who comprise 93% of the special education population of school age (Hofmeister, 1983) -- seems even more momentous. Touted for this group as the supreme motivator, the infinitely patient tutor, and the ultimate provider of individualization, the microcomputer has fired the imaginations of many concerned with uncovering ways to tap and maximize the potentials of the approximately four million school-age Americans (Plisko, 1985) who fall into this category.

But is the promise being fulfilled? Does ongoing, day-to-day instructional use of the microcomputer with students with various handicapping conditions actually promote the benefits ascribed to computer based education (CBE) for this population? How effective, in particular, is CBE for learning disabled (LD) students -- the single largest group of school children with handicapping conditions (Plisko, 1985)? And what elements contribute to that effectiveness (or lack thereof)?

Need for the Study

There is surprisingly little empirical evidence to support the claims of the enthusiasts for CBE with students who have mild learning handicaps (MLH). Only a few studies that address the instructional effectiveness of computer courseware for this population can be found among the
plethora of publications that survey the current number and uses of computers in special education; decry the lack of courseware developed specifically for learners with special needs; offer suggestions for evaluating, selecting, and implementing what is available; and predict the future of the computer in special education. Moreover, the studies that are available primarily compare CBE with instruction by conventional means and suggest only moderate gains or simple equivalence for students who use the computer. None of the published studies examines in a systematic and rigorous way the actual use of courseware in an ongoing instructional context with students with MLH.

Thus, existing studies neither justify widespread enthusiasm for CBE for special needs students nor provide many insights into the reasons this mode of instruction might be effective with them. In particular, the studies do not consider which specific characteristics of courseware—the *sine qua non* of CBE—are more and less successful in enhancing such students' learning. Until special educators have a great deal more empirically based knowledge about this fundamental area, CBE will be unable to fulfill its promise for mildly handicapped students.

In an attempt to investigate this issue, a case study of the day-to-day instructional uses of microcomputers with a group of LD students of middle school age was undertaken.
to examine the effectiveness of CBE as it is normally used with such students. The primary focus of the research was students' and teachers' interactions with instructional dimensions of the CBE courseware ordinarily offered at the research site. These interactions were analyzed to determine what makes CBE more or less effective as it is currently used by and with the target students. The ultimate purpose of the study was to determine which elements of courseware are and are not effective in an actual instructional setting. This was viewed as the first step in creating guidelines for developing courseware that truly meets the needs of LD students and their teachers.

Research Problems

All the issues addressed in the study can be summarized in the two major problems that guided the research: (a) the need to learn how students with learning disabilities perceive, react to, and interact with various instructional dimensions of the CBE courseware to which they are exposed and (b) the need to learn how teachers of these students perceive various instructional aspects of CBE courseware and use these to enhance their students' learning.
Research Questions

Because the learner's relationship to courseware is the critical element in CBE for any student, including a learning disabled one, dimensions related to the first of these two problems comprised the major foci for the study. These dimensions are delineated below.

I. How do students with learning disabilities perceive, react to, and interact with various instructional dimensions of the CBE courseware to which they are exposed?

A. The particular ways in which the students in the study perceive, react to, and interact with critical components of courseware:

1. The presentation of the stimulus, for example,

   a) elements of concept development, such as the logic and completeness of the presentation and the provision of examples and nonexamples;

   b) features of display design, such as techniques for focusing students' attention by highlighting relevant stimulus characteristics;
c) motivational features, such as instances of fantasy, curiosity, and challenge incorporated into the courseware "scenario."

2. The elicitation of the response, for example,
   a) pacing,
   b) various levels of questioning,
   c) opportunities for practice,
   d) kinds of hints,
   e) amount of interactivity,
   f) consistency/inconsistency of response options.

3. The provision of reinforcement, for example,
   a) kinds and levels of feedback and branching,
   b) overt and covert attempts to enhance students' self-esteem.

B. The strategies that students develop to deal with various kinds of courseware and various levels of difficulty within those kinds:
   1. Academic strategies,
   2. Coping strategies.
C. The effectiveness of courseware with the target students in developing academic skills:
   1. Basic skills, for example,
      a) language arts skills,
      b) computation skills.
   2. Higher-level skills, for example,
      a) improved memory,
      b) problem solving,
      c) divergent thinking,
      d) error handling.

D. The effectiveness of courseware with the target students in enhancing personal development:
   1. Independence,
   2. Self-confidence,
   3. Positive self-concepts,
   4. Feelings of active agency.

And because the role of the teacher is particularly significant in the effective use of CBE with LD students, dimensions related to the second research problem, as delineated below, were also addressed.

II. How do teachers of these students perceive various instructional aspects of CBE courseware and use these to enhance their students' learning?
A. The classification(s) of courseware and particular examples of each perceived by the teachers to be most and least effective for their students and the reasons for these perceptions:

1. Drill and practice,
2. Tutorial,
3. Simulation.

B. The strategies teachers develop to capitalize on perceived strengths and/or to compensate for perceived weaknesses in courseware in order to enhance the value of CBE for their students.

C. The ways in which students' CBE experiences are or are not integrated into ongoing classroom instruction and the reasons and procedures related to this factor.

D. Teachers' perceptions of their students' development of personal and social competencies and basic and higher-level academic skills through CBE.

Bounding the Study

Because the focus of the research was courseware itself, other aspects of CBE were excluded from the study. Administrative uses of the school's computers, for example, were not addressed; neither were computer managed instruction nor computer assisted testing (neither of which
was, in fact, in use at the site during the fieldwork). A wide array of issues related to policies and strategies for introducing and implementing CBE at the site were also judged outside the realm of this investigation. Similarly, statistical measures of overall student performance were avoided because of the study’s primary concern with specific behaviors related to particular instructional dimensions.

In order to allow the most significant of these dimensions to surface during the investigation, no instructional dimensions uncovered during the review of the literature were excluded a priori from the study. Students' uses of such tools as LOGO and a word processing package were not examined because these do not actually deliver instruction and do not therefore contain many of the instructional dimensions under consideration, but all other commercial courseware used during the period of the fieldwork was investigated. Because some packages—especially a math drill-and-practice program—were used far more extensively than others, these received the greatest amount of attention from the researcher.

Observations and interviews were confined to students enrolled in the site's middle and upper divisions, which serve children aged 9 to 17. With the exception of three students whose parents/guardians failed to return consent
forms for their children's participation, all students in these divisions were potential subjects for the study.
CHAPTER II
A REVIEW OF THE LITERATURE

A review of research on the instructional uses of computers with mildly learning handicapped children provided the immediate background for the study, while a review of research and theory related to four fields--instructional systems design (ISD), computer based education (CBE), mild learning handicaps (MLH), and courseware for children with MLH--provided the conceptual framework upon which the study was based. Starting with a review of recent research and continuing through these other topics, this chapter offers a synthesis of findings and insights from this diversity of disciplines to establish the need for the study, to suggest its historical context, and to delineate a number of instructional dimensions examined through it. The review thus supplies both the theoretical foundations and the specific foci for the research effort.

Research Background
Cartwright and Hall's (1974) review of computer uses in special education provided a baseline for research in
this broad field, but their statement of conditions through mid-1973 described a world very different from the current one—a world that did not include microcomputers in daily instructional use with any handicapped population. Introduced to the schools in the mid-1970s, micros became a focus for research only after the Cartwright and Hall article appeared. The years since then—and particularly since the early 1980s—have seen a burgeoning of information on the uses of technology throughout special education.

**Recent Research: An Overview**

A number of resources provide excellent overviews of general issues in technology and special education. Education Turnkey, for example, has been collecting data from a variety of sources since 1981 in order to identify a wide range of needs, applications, and research-and-development efforts in this area. A series of publications reporting these findings (Blaschke, 1984, 1985; Education Turnkey, 1983, 1985) provides historical perspective as well as a continual updating of the current applications of micros in special education, of anticipated trends in the use of these devices and other electronic media, and of emerging policy considerations and decisions.
Another perspective is provided by the joint work of the Cosmos Corporation and SRA Technologies, who conducted case studies in 12 districts across the country focusing on organizational and management issues related to both hardware and software in special education (Hanley, 1983). Rounding out the kinds of general information available about the field are Cartwright (1984), who reviewed a variety of the research related to the uses of micros with various special education subpopulations, and Behrmann (1984), who addressed theory, research, and applications within and across the entire field.

Augmenting these general resources are a number of others focused particularly on the topic of micros and the learning disabled (LD). Chief among these are some of the leading journals in the field, which have responded to the needs and interests of their audiences with special issues, regular features, and individual articles. In the summer of 1982, for example, the cover of the *Journal of Learning Disabilities* announced "a new monthly supplement" entitled "Computers in the Schools." The first articles in this section offered basic information on why the topic is important; surveyed general issues in the field; suggested what hardware to buy; reassured teachers about the continuing importance of their role; and introduced a segment entitled "Coarseware [sic] Review"--a misspelling,
or perhaps a subconscious evaluative statement, corrected several issues later. Beginning with the second issue in which it appeared, the section has been printed on gray stock to highlight it within the journal.

*Learning Disability Quarterly* followed suit in the winter of 1984 with "Microcomputing," a regular column "being introduced in response to the enthusiastic curiosity of educators throughout the nation who deal daily with the LD population" (Cardinal, p. 113). *Academic Therapy* included a special section on micros in its May 1983 issue and inaugurated a "Bits and Bytes" column the following September. Articles in these publications as well as such others as the *Annals of Dyslexia* and *Learning Disabilities: An Interdisciplinary Journal* continue to present information and insights on CBE for LD students.

Much of the writing that appears in these and other forums, however, must be characterized as opinion rather than research. While many of the most prominent figures in the field of learning disabilities have offered insights into various aspects of technology and special education, few of these ideas are grounded in formal, systematic study. As might be expected in a discipline still in its infancy, many of those writing today begin by lamenting the dearth of research in the field. McDermott and Watkins (1983), for example, noted that "Investigations of CAI
[computer assisted instruction] with learning-disabled children are the rarest" (p. 82) among the research efforts in special education and technology. And Cartwright (1984) and McCaslin and Stevens (1984), who reviewed the research for different publications, found relatively few studies to review.

Recent Research: Specific Studies

The most extensive of all the investigations done with the LD subpopulation thus far—and the most extensively cited reference throughout the literature—was the work of Chiang and others (1978) with 200 subjects, aged 7 to 16, about half of whom were LD. Chiang’s two-year effort involved developing and testing a minicomputer based authoring system called "ASSIST: Authoring System Supplementing Instruction Selected by Teachers." Using 10 models provided by the system, the 14 teachers involved in the study created and implemented 811 drill-and-practice lessons (687 in language arts and reading and 124 in math) designed to supplement their regular instruction. Each lesson took approximately 15 minutes to create; on average, each lesson was used 22 times.

The evaluation phase of the project involved the individual administration of standardized achievement tests, on which treatment group students showed an overall
moderate pre- to posttest gain with the highest gain in reading recognition. The author reported that the results of the cognitive outcome evaluation seem to be reliable and indicative of cognitive benefits to the students from their exposure to CAI. This can be considered a remarkable result, given that students spent an average of only 30 minutes per week taking CAI lessons. (p. 31)

Student achievement was not the major focus of the project, however; most of the report dwells upon the nature, creation, and implementation of ASSIST. To the author, the most significant result of the effort—the one stressed throughout the document—seems to be the project's demonstration that such a system can operate reliably and successfully in special education classrooms, as evidenced by the ease with which teachers incorporated CAI with their classroom activities, the large number of lessons they created, the extensive student use of the system, and the overwhelmingly positive response from teachers and students towards the system. (p. 37)

McDermott and Watkins (1983) also studied a large number of LD subjects—79 in a microcomputer treatment group and 126 in a conventional-instruction control group—over an extended period of time—an entire academic year. In this attempt to determine the relative merits of the two kinds of instruction, treatment group students (41 in spelling and 38 in math) used commercial materials that were "specially tailored" (p. 83) in an unspecified way;
control group students presumably received their usual instruction.

Data analyses revealed that the gains for all groups of these first- through sixth-graders were "essentially equivalent" (p. 81)—a result the authors attributed at least in part to the insensitivity of the standardized tests that formed the basis of the evaluation. Cautioning future researchers to use "criterion measures that are adequately sensitive to achievement gains in handicapped learners," these authors concluded only that

it might be reasonable (a) to assign [LD] pupils to CAI programs whenever it appears that this will reduce the motivational deficits and resistance so often detected among problem learners and (b) to recommend special teacher-instructed programs whenever affiliative needs and social conditioning are deemed priorities. (p. 87)

Similar results were reported by Hummel and Hahn (1982), who studied "approximately 90 students" (p. 2), some of whom had been formally identified as LD, from 21 resource rooms in the elementary, middle, and secondary schools of three districts. Dividing this group into three conditions—an experimental group, who received computer literacy training and used math courseware designed by the authors; a usage group, who received no training and used commercial materials; and a control group—these researchers found a significant pre- to posttest gain on
standardized measures only for the middle school students in the combined experimental and usage groups; moreover, the students at this level who had received all their math instruction in the resource room gained more substantially than those who had received part of their instruction in the resource room and part in their regular classrooms.

Problems in the design of the study (e.g., the middle school teachers had all had previous microcomputer experience while the elementary teachers had had none) as well as its execution (e.g., the secondary school participants used their computer time primarily for gaming) call even this modest result into question. Thus, the authors seem justified in concluding only that "It may be that computers are effective in remediating math deficits for some students and ineffective for others" (p. 12).

Trifiletti, Frith, and Armstrong (1984)--evaluating their SPARK-80 Computerized Mathematics System with 9- to 15-year-old LD students in a private school--did find significantly greater results for the computerized instruction group compared to the resource instruction group in terms of number of math skills mastered and fluency of problem solving [as well as] over twice the yearly gains in achievement and in number of math skills learned. (p. 69)

These results, however, are more readily explained by the research conditions than by the CBE itself: each of the 12 target students spent 40 minutes a day using the
microcomputer and was encouraged to complete correlated paper-and-pencil homework to earn an additional 5 minutes of time each day to play computer games. The 9 control group students "received traditional resource room mathematics instruction from experienced teachers for 40 minutes per day" (p. 69), during which "Both [teachers] presumably taught the skills that appeared deficient based on [the standardized] instrument" (p. 71) used as the basis for the study's pre- and posttest measures. No mention was made of any homework assigned to the control group students, and the authors themselves acknowledged a lack of information about resource room conditions—including not only what was taught but also the amount of individualized attention received by each student.

Lally (1981), reporting on several years' work with an unspecified number of "intellectually handicapped school children" (p. 3) in Australia, described several experiments using computer technology to direct students' attention to relevant aspects of tasks in vocabulary development; concept formation; and, primarily, handwriting. Drawing on techniques derived from video games, Lally designed activities for unspecified "larger machines" (p. 15) and found that "this type of instruction is a useful adjunct to more conventional methods" (p. 3) in the three areas he investigated.
Several single-subject studies have reported the effective use of CBE with LD students. Pollard (1979), for example, reported that a 10-year-old Australian dyslexic boy for whom "words had acted as a sentinel barring entry" (p. 8) learned to read through microcomputer activities programmed by his father. Recognizing the contributions of university faculty in developing the final sequence and content of these mastery activities, Pollard asserted that in three months the boy had been introduced to over 2,000 words and several stories by this means.

Hasselbring (1982, 1984), using an ABAB design to compare the effects of the same strategy delivered by a teacher and by a microcomputer, reported that the computer was as good as, if not slightly better than, the teacher in improving the spelling of an 11-year-old LD male. The strategy involved (1) praising the student for each correctly spelled word, (2) explaining his error when he misspelled the word, (3) showing him the correct spelling, and (4) requiring him to spell the word correctly before moving on. Citing the comparability of results in the two conditions, Hasselbring noted that "these observations suggest that microcomputer-based feedback is as effective as teacher feedback" (1984, p. 14) in this situation and cited cost and time benefits that would result from the use
of the Computerized Spelling Remediation Program (CSRP) he had designed for the study.

In one of the few studies focusing on commercial rather than researcher-designed materials, Sisson (1983) reported success in using a game to teach learning strategies to an 11-year-old boy whose "achievement lag was never quite low enough to meet the criteria" (p. 7) for him to be labeled LD but whose description strongly suggested that he fit into this classification. According to Sisson, the boy developed strategies for learning to learn. He classified ideas, synthesized new rules and used them to solve problems. He learned to predict possibilities which he could then verify through actual experience. He developed the implications of strategies on one program which he could then try with another. (p. 8)

Despite such testimonials—and there are many in the popular and practitioner press as well—it is clear that research into the effectiveness of CBE with LD children is at present sparse, uneven, and unsatisfying. For one thing, most studies are efforts to evaluate materials designed by the researchers rather than to examine students' use of the commercial courseware that Hanley (1983) reported to be the most frequently used in classrooms. For another, although the different levels of hardware used in the studies are noted in the reports, no distinctions are made among the different learning
environments that might be afforded by each type.

The more serious problems, however, exist at a deeper level. Prolonged investigations with large numbers of students yield minimal results that hardly justify the time or effort expended on the research. Seriously flawed studies form the basis for unwarranted generalizations about the wholesale advantages and disadvantages of one delivery system over another. Single-subject studies provide some insights, but these efforts are often vaguely described and their findings are too discrete to suggest any larger patterns. Most disturbing of all, perhaps, is the fact that many of the reported findings simply restate what has long been known about time on task: it should be no surprise that supplementary CBE improves learning, since increased engaged time on a learning task under any strategy is likely to have the same result.

Stymied by the difficulties of controlling all the relevant variables, of drawing strong general conclusions from widely varied applications with a heterogeneous population, and of gaining useful knowledge from cross-method comparisons, researchers are currently recognizing the importance of taking their efforts in a new direction. Perhaps Hanley (1984), suggesting to the National Association of State Directors of Special Education a more appropriate agenda for research in the
area, expressed most cogently both the present problems and the future possibilities:

Research on the use of CAI in special education has been scant. . . . most of the studies in this field have been small and have concentrated on substantively different applications with different handicapped populations. It is difficult, if not impossible, to generalize broadly from such diverse experiments.

The effectiveness of CAI [as a medium is] a non-question. . . . Ultimately, more controlled analysis of CAI software is mandatory. Many authors . . . have identified particular features of CAI software that should be considered. Much of this writing has, however, been subjective; solid educational principles are reflected in the opinions of the authors but the relative importance of the chosen features has not been extensively tested. The goal of this research would be to provide an understanding of the elements of CAI . . . that contribute to [its] appropriate and effective use. (pp. 50, 59-60)

Theoretical Framework for the Study

Hanley cited three authors whose 1983 publications specify a few elements of courseware that need further examination. Indeed, there have been many other scholars, working over a much longer period of time, whose insights suggest hundreds of specific dimensions that lend themselves to investigation. A consideration of the range of these elements—as identified through writings on instructional systems design (ISD), computer based education (CBE), mild learning handicaps (MLH), and courseware for students with MLH—is necessary to yield a
framework to guide any truly comprehensive and systematic research.

Beginning with the broadest of these fields--ISD--this section of the review successively narrows its focus through the other areas to concentrate finally on the emerging field of courseware design for MLH students. Rather than comparing and contrasting the relative contributions of each discipline, the section stresses instead the cumulative and coherent nature of the knowledge base underlying the design of courseware for such students. The section thus serves as a document of record noting the scope of general and specific information that guided the research effort.

**Instructional Systems Design (ISD)**

Theory and research related to ISD provided the broadest historical and conceptual framework for the study and also introduced a number of instructional dimensions considered important for MLH students as well as for "average" learners. An area of considerable interest for well over 20 years, ISD has drawn from psychology, engineering, business, and media (Briggs, 1982) to establish principles and identify issues that relate to instructional materials in general and, by extension, to the particular concerns of this study. In his classic work
in this field, for example, Briggs (1977) argued forcefully for the presentation of the content of instruction in a highly structured, carefully organized sequence built around clearly stated objectives that enable learners to understand the relationship between the tasks they are asked to perform and the learning they are expected to master. All Briggs's principles for designing instructional materials focus on ways to foster logical but flexible presentation of information, practice of skills, and provision of evaluation as each of these three phases is matched to the learners for whom the materials are designed.

Gagne (1977) performed the invaluable service of delineating theoretical and practical relationships between the field of cognitive psychology and the field of instructional design. His specification of eight instructional events, each linked to a particular phase of the learning process, provides comprehensive theoretical and practical guidelines for identifying dimensions that should be incorporated into instructional materials to encourage and support each phase of any learner's cognitive processing. A simple list of these learning phases and the instructional event(s) related to each implies a wealth of dimensions to examine in relation to CBE courseware for LD students:
I. Motivation phase (expectancy):
   Events:  1. Activating motivation.
            2. Informing learner of objective.
II. Apprehending phase (attention; selective perception):
    Event:  3. Directing attention.
III. Acquisition phase (coding; storage entry):
            5. Providing learning guidance.
IV. Retention phase (memory storage)
V. Recall phase (retrieval):
VI. Generalization phase (transfer):
VII. Performance phase (responding)
VIII. Feedback phase (reinforcement):
     Event:  8. Eliciting performance; providing feedback. (p. 285)

Gagne's suggestions of specific instructional techniques to use for enhancing learner performance in each of these phases also suggested a number of instructional dimensions relevant to the study: using novel stimuli and emphasizing these with various kinds of typefaces, color, graphics, and animation; providing a variety of examples; asking questions and providing directions; using pictures and graphs to suggest schemes for encoding; requiring students to perform and thus to be active rather than passive learners; prompting and cueing as appropriate; providing frequent corrective and informative feedback; and rewarding learning in ways that will enhance motivation and thus encourage further learning.

If Briggs's and Gagne's work laid out the tenets of ISD that provided both a general framework and some
specific foci for this investigation, other researchers in this tradition provided more detailed discussions of many particular instructional dimensions that were also of interest. Merrill and Tennyson (1977), for example, cited the critical importance of using an adequate number and range of examples and nonexamples and of providing sufficient opportunities to practice differentiating among these by arranging them in random sequence and accompanying each with feedback. And Fleming and Levie (1978)—in their compendium of 193 principles that summarize the outcomes of a wide variety of research in behavioral and cognitive psychology—suggested a host of dimensions to investigate in order to determine the effectiveness of instructional materials in guiding sensory perception, encouraging concept acquisition, and facilitating the encoding of concepts in long-term memory. These dimensions reflect a number of considerations mentioned above and introduce many others as well—for example, using simple, closed, symmetrical figures and the simplest visual representation a concept will allow; using more than one sensory modality; beginning with concrete concepts and moving to the abstract; using repetition, cuing and the gradual fading of cues, and practice that is spaced rather than massed; interspersing questions, particularly higher-level ones, in instruction; and providing opportunities to practice in
realistic contexts what has been learned.

**Computer Based Education (CBE)**

Drawing heavily upon theoretical and practical principles garnered through ISD research, scholars and practitioners in CBE—the second tradition of interest to this study—began in the 1970s to turn their attention to specific dimensions that contribute to the generally positive effects of this mode of instruction as noted in the classic reviews of the research by Edwards, Norton, Weiss, and Dusseldorp (1975); Thomas (1979); Kulik, Kulik, and Cohen (1980); Kearsley, Hunter, and Seidel (1983); and Kulik, Bangert, and Williams (1983). Highlighting dimensions specified through ISD efforts and expanding this focus to include issues and dimensions particular to the interactive learning situation provided by the computer, writers in this area provided many additional insights about instructional dimensions that are potentially important for the general learner as well as for the subjects of this study.

Hall (1982), for example, suggested a number of attributes that should be included in the instructional environment created with CBE: "(1) frequent feedback to learners, (2) tutorial relationship, (3) individual pacing, (4) individual programming, (5) clarity of presentation,
(6) motivational factors, (7) variability in classroom activities, (8) enthusiasm, (9) task-oriented or achievement oriented instruction, and (10) opportunities for students to learn criterion material" (p. 362). Clearly these attributes are significant for handicapped as well as nonhandicapped learners--as is Hall’s later (1983) augmentation of this list with his suggestion that

Probably the single most important factor in producing courseware of a high educational quality is the nature of the questions which are presented to the learner. High-quality courseware must incorporate questions which cause learners to respond throughout the range of Bloom’s taxonomy. (p. 6)

Malone (1981; reprinted 1984) found that challenge, fantasy, and curiosity are the key motivational ingredients in computer games and argued (1983) that these attributes should be built into courseware as well. Thus he suggested that effective courseware should include clear, meaningful, and appropriately difficult goals; uncertain outcomes at variable levels of difficulty to be determined automatically or by the student or the "opponent" computer program; multiple goal levels provided by scorekeeping routines or response opportunities speeded according to the student’s ability; randomness; emotionally appealing fantasies that are intrinsically related to the skill to be learned and that provide "metaphors or analogies that help a learner apply old knowledge in understanding new things"
(1983, p. 244); audio and visual effects to enhance sensory curiosity; and surprises followed by constructive feedback that helps the learners to "remove the misconceptions that caused them to be surprised initially" (1983, p. 246). The incorporation of dimensions like these to increase the motivation of students who must overcome a variety of difficulties in order to learn seems a natural application of Malone's findings.

On another front, commercial and academic organizations concerned with the development of effective courseware have vastly expanded the lists of critical instructional characteristics generated by specific research studies. For example, the Control Data Corporation's PLATO division (1983) highlighted some 92 considerations related to effectiveness in 15 general areas: courseware content, organization, interaction, response judging and feedback, style, menus, key functions, prompts, display formatting, pictures and graphics, color, sound, routing and branching, data collection, and documentation. Although some of the items concern dimensions that are more managerial than instructional, nevertheless the number of instructional dimensions Control Data suggested as inherent in "a quality product" (p. 3) is significant. And since these items are based on "what we have found effective for designing and developing
courseware products" (p. 1)—presumably through years of experience developing and testing courseware for the PLATO system, the most thoroughly evaluated courseware on the market—one must assume that Control Data's suggestions of important instructional dimensions deserve close attention no less for MLH students than for "normal" ones.

In recent years, a number of attempts to identify and categorize such dimensions have been made. With funding from federal, state, local, foundation, and/or private sources, a number of agencies (such as the Northwest Regional Educational Laboratory, CONDUIT at The University of Iowa, the Minnesota Educational Computing Consortium, the National Council of Teachers of Mathematics, and the Educational Products Information Exchange/Consumers Union) as well as a variety of commercial ventures have tried to identify the important characteristics of high-quality courseware. The published evaluation guidelines resulting from these efforts are designed to help teachers and others determine whether courseware available to them incorporates instructional, technical, and managerial dimensions necessary for effective classroom use (see Jones & Vaughan, 1983). Although not generally identified as significant through rigorous and systematic research, these instructional dimensions deserve attention largely because of the widespread agreement of theorists and practitioners
that they seem to be important and because discoveries regarding the precise nature and degree of their contributions to effectiveness—particularly for MLH students—are obviously still to be made. As Olds (1983) warned,

> It is exceedingly important that any effort at software evaluation recognize that now is not the time for setting firm standards, but rather a time for developing flexible ones. We are at the very beginning of the application of computer technology to education. . . . software development is in its infancy, and so is hardware development. (p. 6)

Thus, a number of previously (in this document) unspecified issues drawn from published evaluation guidelines also suggested areas for the study to explore: the integration of CBE experiences with other instruction and with the curriculum, the reasonableness of a package's scope and length, the appropriateness of its tone, the user's freedom to choose among topics, the provision of nonthreatening feedback that reinforces only correct responses, the use of appropriately clear language and style for directions and examples, the nature of the use of the capabilities of the microcomputer, the theoretical soundness of the content, and the provision of various mechanisms to allow for user control.

While it is apparent that research and theory related to both ISD and CBE have made distinctive contributions to
the general and specific foundations for this investigation, it is important to note that the distinctiveness of these contributions effectively blurs in much of the current writing in this field. Not only are CBE authorities drawing many of their insights from ISD principles, as noted above, but scholars generally associated with the ISD tradition are now bringing their expertise to bear on the design of instruction for computer delivery systems. Thus Gagne, for example, joined with Wager and Rojas (1981) to "propose a system for planning and authoring lessons in computer-assisted instruction" (p. 17) that incorporates Gagne's suggestions discussed earlier into procedures for designing computer based drill-and-practice, tutorial, and simulation lessons. Wager (1982) continued this thrust by calling for "theory based" design of CBE materials—the theory of choice being the ISD one that Wager has worked for years with Briggs and Gagne to delineate and refine.

Recent articles on the characteristics of effective courseware (e.g., Cohen, 1983a, 1983b) have interwoven insights gained through theory and research in both traditions to highlight dimensions potentially significant for handicapped and nonhandicapped students alike. These articles have addressed such dimensions as the inclusion of higher order skills; formats conducive to easy reading; the
provision of demonstrations; the nature of the student's sequence through the lesson (linear or flexibly branched); embedded, appropriately used graphics; animation; amount of learner control over rate of presentation, exiting and re-entering a lesson, reviewing information, and altering such parameters as the number and difficulty of items; the presence of "HELP" and "HINT" options; branching to various levels rather than simply looping back through previously presented information; nonthreatening, remediating, and relevant feedback that neither overpraises for every correct answer nor reinforces incorrect responses through providing more rewarding graphics for these than for correct ones; record storage; random generation; and the provision of adequate teacher and student manuals.

**Mild Learning Handicaps (MLH)**

A third tradition of research and theory both complements and extends the conceptual and practical framework for the study suggested through the discussions of the ISD and CBE traditions above. This tradition—MLH, and especially learning disabilities (LD)—has developed almost entirely since World War II, as special education in general has advanced in knowledge and prominence during this period. In particular, the initiation of many programs after 1961 and the national commitment to the
educational rights of handicapped citizens represented by the passage of P.L. 94-142 in 1975 provided the impetus that has led to many advances in this field (Hallahan & Kauffman, 1978).

Ever since 1963, when Samuel Kirk first proposed the term "learning disabled" to describe students with mild learning problems who did not fit appropriately into such traditional special education categories as mild mental retardation and who were poorly served by such labels as "minimally brain-injured" and "perceptually disabled" (Hallahan & Kauffman, p. 120), researchers in this newest category of special education have worked to describe fully the characteristics of this disability and to find solutions to LD students' problems in the classroom. Perhaps somewhat ironically, as work in the field has progressed, a number of theorists have moved away from the notion that these problems are unique to LD learners and are now advocating a noncategorical approach to the education of LD, mildly retarded, and mildly behaviorally disturbed students. This movement is based on two general arguments:

1. It is not possible to separate children distinctly into each of the three areas based upon psychological, educational, and behavioral characteristics.
2. Based on the extensive overlap of psychological, educational, and behavioral characteristics, teaching methods and
approaches are very similar for each of the three areas. (Hallahan & Kauffman, pp. 45-46)

It seemed prudent to conclude at the beginning of this investigation, then, that insights into the needs, abilities, and educational techniques related to all three categories could provide background information for any one. More specifically, it seemed reasonable to assume that instructional dimensions specified as important for this broad group of students should be addressed in relation to courseware used by the particular students who were the focus of the research. Such a view would certainly be supported by Cartwright (1984), who prefaced his review of computer applications for MLH students with a brief restatement of the rationale for the noncategorical approach and the observation that "Thus, you will see a good deal of overlap among these groups in the literature" (p. 172).

Many considerations related to instructional materials that are effective with these students pick up threads of principles and issues interwoven throughout the previous sections of this review. An early attempt to establish criteria to use in evaluating and selecting instructional materials for handicapped students, for example (National Center on Educational Media and Materials for the Handicapped, 1976), suggested a general framework for such
materials drawn directly from the ISD tradition: a systematic approach to development based on curricular needs and specified objectives and matched closely to specified learner characteristics. Within this framework, a number of specific instructional dimensions also echo those cited earlier in this review (e.g., multisensory approach, use of a variety of stimuli, attention to visual arrangement and color) while others address some issues more directly related to special education: use of game formats; provision of immediate feedback; particular attention to readability, ease of use, and level of complexity; absence of distracting elements; use of simple, "cartoonlike" graphics; figure-ground definition; amount of teacher involvement required; presentation of handicapped and other minority persons in objective and positive ways; instruction in required subskills; systematic introduction of vocabulary; self-pacing; frequent reinforcement of major concepts; summaries and reviews of major points; and "frequent opportunities for active student involvement and response" (p. 9).

The years since the introduction of these standards have seen various attempts to clarify and expand upon them in discussions of instructional design considerations for special needs students. Couched frequently in terms of the operant model (antecedent-behavior-consequence, also
expressed as stimulus-response-reinforcement) that undergirds applied behavior analysis, these attempts have often focused on instructional dimensions of special importance to MLH students. Sulzer-Azaroff and Mayer (1977), for example, discussed various techniques both for bringing under stimulus control those responses that are within a learning handicapped student's behavior and for getting appropriate behaviors into that student's repertoire. These authors suggested using the stimulus-change procedure and differential reinforcement to encourage the production of responses the student already has. They also cited the importance of clearly identifying the most salient characteristics of the stimulus material presented to students, focusing students' attention directly on these, and using effective reinforcement procedures when a correct response is emitted in order to help the student learn new responses. Some particular instructional dimensions related to each of these concepts include the emphasis of stimulus characteristics through magnification, color, or highlighting; the provision of verbal and visual prompts to encourage student responses; the use of fading and shaping to guide learners to respond correctly to the appropriate stimuli; and the incorporation of a continuous reinforcement schedule during initial learning and an intermittent schedule during maintenance.
Bailey (1981), speaking specifically to the tendency of LD students to be overselective in their responses to stimuli, suggested both teaching students to attend to relevant stimulus characteristics and emphasizing these in some way (by color cueing, highlighting, or providing textual cues) to focus students' attention on them. Vargas (1984) noted the prevalence of inappropriate stimulus control in printed student materials and cautioned against stimulus presentations that occasion students' responses to pictures, formats, highlights, and grammatical cues rather than to the text the learners are supposed to be processing. And Hall, Delquadri, and Harris (1977) argued that perhaps no other instructional dimension is so important to learning as the provision to students of many opportunities to respond actively to stimulus materials in various forms and contexts.

Courseware for Students with Mild Learning Handicaps (MLH)

Although the use of large computers for teaching handicapped students has received generally favorable reviews (Cartwright & Hall, 1974), instructional promise was not the primary focus of early popular and research literature on the use of microcomputers with this population. Instead, a great deal of early interest in this area focused on adaptive devices to aid the physically
or sensorially handicapped in communicating with others or in controlling their environments. And while increasing attention is currently placed on using micros to assist in the education of students with the full range of learning handicaps, much of the information available in this field still addresses various management applications that teachers and administrators have found useful: student assessment and record keeping, the generation of Individualized Education Programs, and the development of various documents mandated by state and federal agencies.

Recently, however, there has been an upsurge of interest in the instructional uses of micros for students with handicapping conditions. Striking evidence of this is provided by the staggering increase in the amount of courseware developed for this population between 1981 and 1984. According to Education Turnkey (1983), "Of the 1,200 courseware titles offered in the catalogs of major courseware publishers in December 1981, fewer than ten were designed specifically for special education" (p. 12). Writing two years later, Blaschke (1985) noted that "In 1983/84, three firms . . . released more than 100 programs which allow special education teachers to adapt or adjust the courseware for special education students" (pp. 74-75). Contemplating the future, Education Turnkey (1985) predicted that
In the next two years, a large number of useful software packages will be available to satisfy many . . . of the needs of special education students and staff. An increasing number of publishers and developers can be expected to announce adjustable courseware packages which can be used with handicapped learners. (p. 31)

In addition to having more specially designed courseware to use, special educators continue to rely upon the regular education courseware they have tried over the years (Hanley, 1983) and modified to meet the needs of particular kinds of students. Both alternatives--adapted and unadapted courseware--must obviously share the same characteristics if they are to be effective with MLH students. And, not surprisingly, many of these characteristics are the ones considered important for students without learning handicaps as well. As Taymans and Malouf (1984) noted:

Handicapped students, particularly those labeled mildly handicapped, learning disabled, behavior disordered, and mildly or educable mentally retarded (which together comprise by far the largest segment of the handicapped population) may not be as different from nonhandicapped student populations as is sometimes believed. . . . Well-designed software, in fact, can be used effectively with a wide range of students, handicapped and nonhandicapped. (p. 13)

Much of the theory and research regarding courseware design for MLH students reflects this view, simply assuming principles and ideas interwoven throughout the discussion of general design considerations presented above. Far from
representing an exclusive and exhaustive list of courseware characteristics critical to these students alone, the issues and dimensions highlighted by theorists in this field can often be seen more accurately as restatements and/or specifically targeted refinements of many of the ideas discussed in the paragraphs above.

Hannaford and Sloane (1981), for example, in their "Evaluation Form for Microcomputer Software" designed specifically for special educators, echoed a number of items raised on the general checklists mentioned earlier. Hofmeister (1982) noted that "the computer's capacity for conceptual teaching will prove to be more important [than drill and practice] in terms of relative contributions to the field of special education" and cited as his reason the computer's ability to present "a rich reservoir of examples and nonexamples" to special students in a "carefully assembled, carefully matched, and carefully managed" way (p. 117). And Metzger, Ouellette, and Thormann (1983)--in their booklet Learning Disabled Students and Computers: A Teacher's Guide Book--began their discussion of evaluating software for such students with the assertion that

Software that is appropriate to use with L.D. students must meet general criteria for software that is appropriate for any student, as well as additional criteria that addresses an L.D. student's special needs. Good software is based on sound instructional theory and assists
students in meeting clear educational objectives.  
(p. 29)

Expanding upon this general statement, these authors listed a number of points they say should be considered when reviewing courseware to be used with LD students.  

Significantly, these same considerations appear in lists of criteria for courseware for the average learner as well:

- The directions for the student should be clear and at an appropriate level.  
- The reading level throughout should be appropriate and consistent for the task and the student.  
- The program should reflect the age and interest level of the student.  
- The time it takes the student to complete the program must fit the teacher's plan of instruction.  
- Minimal teacher supervision should be required.  
- The student response rate should be high. Thus, the program should make full use of the interactive capabilities of the computer.  
- Skills learned or practiced on the computer should relate in some way to the student's instructional program.  
- Graphics should be integrated and should actually support the instructional goals of the program.  
- Prompts or hints should be provided only when needed.  
- Criteria for mastery should be clear and consistent. . . .  
- Feedback for responses, both correct and incorrect, should be appropriate. . . .  
- The number of inappropriate student responses allowed by the program should be limited.  
- It is especially important that L.D. children use programs that allow them to exit easily, save what has been done and return to the program at a later time. . . .  
- The program should match students' skill levels and needs. Students should have the prerequisite skills required by the program.  
(pp. 30-31)
Several authors have dealt with dimensions considered particularly important for students with special needs. The Hannaford and Sloane checklist mentioned above, for example, speaks to a number of issues related specifically to this population: relevance to daily living experiences and needs, variety of types of reinforcement, appropriateness of the time requirements of the program, provision of a mechanism to alert the teacher to a student who needs assistance, extensive and extremely flexible branching, and the inclusion of many opportunities for easy exit and re-entry.

Grimes (1981)—reporting on work conducted under Project MASS (Microcomputer Assistance for Special Students) and funded by the U.S. Department of Education—noted that special students generally need additional structure and practice in any instructional situation and cited a number of considerations to build into courseware to address these students' problems in the areas of selective attention, variable reaction times, short-term memory, recognizing mistakes, transferring learning, motivation, and social skills. Among Grimes's suggestions are keeping printed commands simple and consistent; teaching basic "computer" vocabulary; limiting the amount of information on the screen; deleting unnecessary words in
directions and in the presentation of instruction; "highlighting the stimulus value of the information to be learned and reducing unwanted or competing material" through such techniques as "color cueing, animation, underlining, directive arrows, or a box around the information that is most important" (p. 49); using multistimulus cues and large amounts of blank space; adjusting required response rates to meet various kinds of student needs; providing prompts, many examples, and periodic reviews of important materials; using personalization and generous amounts of positive reinforcement; and pairing students for computer work to help them develop social skills.

Hannaford and Taber (1982) restated many of the dimensions Hannaford and Sloane had isolated earlier and also stressed the importance of courseware's providing for "assessing student entry-level performance and subsequent branching to the appropriate level of content," emphasizing "the use and recall of previously learned material," and "enhancing retention and encouraging transfer of learning" (p. 140). These authors also noted the importance in special education courseware of making required responses simple (e.g., typing only a number or letter rather than a phrase or sentence), of making response acceptance flexible, of avoiding the problem of students' getting
"trapped" in a program if they are unable to respond correctly, and of providing feedback to correct responses that includes reasons why the response was correct.

Extending earlier insights even further, Hannaford (1983) suggested that courseware for special students should also incorporate individualized types and schedules of reinforcement; congruence between the topic being addressed and the reading level required; accuracy of content, organization, and language ("Spelling does count!", p. 16); and flexibility that allows the teacher to tailor the instruction for individual students and the student to control his or her route through the tailored program. Also building upon her earlier work, Taber (1983) developed a checklist for software evaluation that added to the catalog of important dimensions such elements as appropriate sentence length, syllabication for new and/or unfamiliar words, and variable and random reinforcement "established by behavior management principles" (p. 23).

Senf (1983) noted that individualization is the key to teaching LD students and argued for learner-specific content, branching based on close task analysis, and the differential rewarding of responses. Delving more deeply than many into the issue of individualization, Senf suggested that "Trusting individualization solely to program branching based on learner performance ignores the
likelihood that some altered situation would drastically change performance." He posed a number of specific questions he believes would be "instructive in focusing concern on courseware itself"—questions that do indeed suggest a more comprehensive understanding of the problems and potential inherent in making such courseware effective:

How would a child with a short-term memory deficit perform if the wait time to respond were long? Would an inattentive or hyperactive youngster perform well if s/he were unable to control the onset of successive items? Would the fragile ego of the failure-prone student survive the "blows" necessary for the program to branch to simpler fare? And if children fail items for different reasons, would not the selection of the same subsequent items be incompatible with the learning needs of many users? (p. 19)

Senf's sensitive probing of the implications of the buzzword "individualization" for LD students is indicative of a trend in more recent writing on the subject to go beyond a simple listing of dimensions thought to be important for MLH students to attempts to explain the ways in which these dimensions are significant. Several authors (e.g., Berkell, 1984; Weisgerber, 1984; and Hofmann, 1985) have pointed out that what is effective for one MLH student—such as color cueing—might be distracting for another. Taymans and Malouf (1984) discussed a number of possible approaches in terms of the specific ways in which they might ameliorate MLH students' known deficits: presenting information progressively to forestall impulsive
responses; using verbal cues, animation, and directive arrows to overcome problems in perception and attention; and employing a number of techniques to circumvent memory difficulties—presenting information in small steps, requiring frequent responses and giving immediate feedback, and using cues (sound, motion, and color) to help students make initial connections.

Similar insights can be gleaned from the numerous articles that touch on one or two dimensions considered important by the authors as well as from reviews of particular courseware packages appearing regularly in special education journals. Although these sources offer concepts chosen at random rather than systematic or exhaustive catalogs, they nevertheless suggest a number of other dimensions potentially of significance. Candler and Johnson (1984a and 1984b), for example, highlighted the value of consistent formats for setting students' expectations, of remediation that includes demonstrations of correct procedures as well as statements of correct answers, and of expressing complex concepts in simple sentences.

To date, the most systematic and perceptive reviews of courseware for LD students have resulted from the activities of the Learning Disabilities Courseware Assessment Network (LDsCAN)—a service sponsored by the Journal of Learning
Disabilities, which publishes the reviews. Based on actual tryouts of courseware by LD specialists with their students, these reviews focus on the utility of the courseware specifically for LD students and discuss particular matches (or mismatches) between features of the courseware and student needs.

Compiling the reviews for the Journal, Mather (1984a, 1984b, 1984c, 1985) praised some packages for controlled reading levels, techniques for analyzing students' errors, graphic isolation of reinforcement from other material on a display, and contemporary content. She criticized other packages for excessive reading, overstimulating graphics, and an amount of reward that slows the pace of the student's progress through the courseware. Hummel (1984, 1985d) wrote positively about interesting and enjoyable sound effects, minimal keyboarding requirements, wide ranges of objectives, and ranges of activities likely to match the ranges of abilities among LD students; he expressed concern about courseware that uses incentives that are external to the learning task and in which the "game . . . is the central interest and [the subject matter] is incidental" (Hummel, 1985c, p. 242).

Many of the most recent reviews in this journal (e.g., Mather, 1984d; Hummel, 1985a, 1985b, 1985d, 1985e, 1985f) have stressed the need for flexibility provided by
management options or "built-in authoring systems" (Hummel, 1985a, p. 118) that allow the teacher to adjust such parameters of courseware as levels of difficulty, rates of presentation, and even response modes. This call for flexibility echoes similar emphases throughout the field (see especially Hanley, 1983; Blaschke, 1985; and Hummel and Farr, 1985).

In another vein, Chaffin, Maxwell, and Thompson (1982) veered drastically from many of the premises upon which special education instruction has traditionally been based (defining "success" as the number of correct responses, requiring near 100% accuracy at one level before allowing a student to proceed, teaching to students' individual needs, and avoiding high-pressure situations) to suggest that courseware for special students should incorporate the motivational aspects inherent in video arcade games. Drawing heavily on Malone's work (1981; reprinted 1984) described above, these authors argued for the inclusion of instructional dimensions that are either not mentioned by others in the field or are mentioned in very different ways. Chaffin et al. suggested, for example, that feedback might consist not of reasons that responses are right or wrong but of a constantly updated score that encourages students to learn what contributes to or detracts from performance and therefore to deduce what is necessary for
improvement. They noted the importance of an ever-present opportunity to improve one’s score through gaining familiarity with the game and its patterns and then developing strategies to increase accuracy. They stated that responding at a fast pace requires undivided attention and therefore eliminates interfering and distracting thoughts. Finally, they wrote that an unlimited ceiling on performance provided through successive increases in the difficulty level leads students not to feel "frustration, discouragement, and disillusionment with the task" but to "continue to improve their skills as their coordination and response times increase and as they employ more effective strategies" (p. 175). Believing that the inclusion of these dimensions counters boredom, teaches handicapped students "to tolerate entry situations with high error rates and to value improvement" (p. 176), encourages speed as well as accuracy in performance, deemphasizes teachers' focus on students' deficits, and creates high levels of involvement, Chaffin et al. represent a revolutionary perspective on the instructional dimensions of courseware that might be most critical to MLH students.

The authors incorporated these dimensions into their design of a number of drill-and-practice programs they call "Arcademic Skill-builders." Although the explicit purpose of this material is to encourage students to develop basic
mathematics and language arts skills, perhaps its most important and original contribution to the emerging field of CBE for MLH students is its implicit cultivation of learning strategies. For example, despite years of comprehensive and detailed work based on a separate body of theory and research indicating that LD students' difficulties in acquiring and using such learning strategies as imaging, rehearsing, and categorizing are at the heart of their learning handicap, the University of Kansas Institute for Research in Learning Disabilities reported—somewhat surprisingly—no past or current investigations on the use of computers to enhance students' abilities in this area (personal communication, Autumn 1983). Extrapolating from the implicit assumptions of Chaffin et al. to examine directly the ways in which CBE courseware can be and is being used to help LD students develop both academic and coping strategies might thus yield critical insights into the dimensions of courseware that are in fact most significant for LD middle school students. Both Rude-Parkins (1983) and Sisson (1983) have indicated a need for further investigation into this topic.

Rubin and Weisgerber (1985) also echoed the learning strategies approach by focusing on the role of CBE in helping LD students become more efficient at cognitive processing. Basing their own instructional design work on
"models of perception and cognition, 'theories' of instruction, and key characteristics of intelligent technologies" (p. 84), these authors described their attempts to develop courseware for teaching the enabling skills underlying reading. Weisgerber (1984) listed a number of these skills—cue differentiation, scanning, pattern recognition, chunking, contextual cueing, memory-building skills, letter recognition, word recognition, and sentence-attack skills—in the theoretical document underlying Project CREATE, the federally sponsored project through which he and his staff are currently designing and testing their materials. Weisgerber and Blake's (1984) eight-page courseware evaluation form devised as part of this project both breaks down these target areas even further and suggests a number of other dimensions—for example, automatic adjustment to individual ability levels—considered critical by project staff.

Summary

Reviewing recent research on CBE with MLH students clearly indicates a need for further, more detailed investigations of the instructional dimensions of courseware that might be most effective with such students. And reviewing theory and research from ISD, CBE, and MLH—particularly courseware design for MLH students—
clearly results in a bewildering array of dimensions that any such study might profitably examine.

Throughout all the literature, however, a number of recurring themes suggest categories of dimensions that seemed to the researcher to be especially significant in their contributions to the effectiveness of CBE with LD middle school students: (a) elements of display design, (b) methods of concept presentation, (c) varieties and levels of response, and (d) types of feedback and reinforcement. These themes—as well as the traditional categories of stimulus, response, and reinforcement provided by the operant model—suggested the primary organizational scheme for the study. Moreover, the literature review itself as well as the researcher’s years of experience as an instructional designer and her conduct of a pilot study for this research during the spring of 1983 suggested additional salient issues that expanded the perspective offered by this primary organizational scheme: the significance of learning strategies and the role of the special education teacher in making CBE an effective tool for this group of students.
CHAPTER III
METHODOLOGY

The study was conducted and reported according to established tenets and procedures of naturalistic inquiry that have been identified as pertinent to educational research by Schatzman and Strauss (1973), Guba (1981), Bogdan and Biklen (1982), and Miles and Huberman (1984a, 1984b). The particular form of the research was the case study—"a detailed examination of one setting, or one single subject, or one single depository of documents, or one particular event" (Bogdan & Biklen, p. 58).

Rationale

As Guba (1981) noted, when choosing an approach to educational research "it is proper to select that paradigm whose assumptions are best met by the phenomenon being investigated" (p. 76). The researcher's decision to approach this study through the naturalistic paradigm was supported primarily by those authors whose views about computer based education (CBE) reflect this paradigm's key assumptions about "the nature of reality . . . the nature
of the inquirer/object relationship . . . [and] the nature of 'truth statements'" (Guba, p. 77).

Many CBE experts have cited the need to acquire more in-depth information about the effectiveness of courseware as it is actually used during normal instruction. Reflecting the naturalistic view that reality cannot be separated into independent parts but must be studied in light of its interrelationships, such authors are interested in the instructional dimensions of courseware not as isolated fragments but as they are actually encountered in context. Cohen (1983b), for example, argued that the ultimate understanding of the instructional efficacy of courseware will come not from examining individual pieces of the puzzle in laboratory settings but from studying the entire picture in its natural environment:

Actual instructional effectiveness may be more than the sum of its parts, and responses to a list of questions may only give intellectual answers to theoretical questions. It is essential that we go beyond the objective theoretical realm of "evaluation" per se and see how the program will be used by the teacher in the classroom, determine subjective motivational elements, and watch the students use the program. The ultimate questions that must be asked are, does the student like the program and will he or she learn anything from it? (p. 16)

Implicit in Cohen's argument is also the naturalistic assumption that reality inheres in individuals' perceptions
of it rather than as an abstraction existing without context.

Della-Piana and Della-Piana (1982) also revealed a belief in multiple realities in their assumption that "the portrayal of the structure of a specific piece of courseware will vary for different audiences" (p. 5) and in their efforts to describe "author-defined . . . student-defined . . . [and] ideal-defined" (pp. 5-6) domains of courseware according to the data particularly relevant to each perspective. Having decided to base their own courseware criticism efforts "in part on a form of naturalistic inquiry" (p. 5), these authors even cited Guba in their article and discussed their use of techniques he had described.

These techniques—for example, close and prolonged observation and sensitive and probing questioning of students and teachers as they interact with courseware in the natural setting for which it was designed—imply the Della-Pianas' (1982) adherence to the second assumption underlying naturalistic inquiry, the belief that the inquirer and the respondent are interrelated rather than independent. The nature of the four questions and probes these authors suggested using with students reflects a view that interaction rather than distance yields the most valuable results of research:
1. What was the lesson about? Tell me more.
2. Do you think this kind of work will help you? How?
3. What were the difficulties you encountered in going through the lessons?
4. Would you recommend this program to other students? Who would they be? Why? Why not? (pp. 34-35)

The same stance toward the inquirer/object relationship was suggested by Cohen (1983b), who argued that educators must not only determine objectively whether courseware is well designed and uses the unique capabilities of the microcomputer but must also "transcend the objective and enter into a more subjective frame of mind" to determine the instructional effectiveness of a given piece of courseware:

The program must be tried out with students and subjective judgements need to be made, such as, does the student like the program, is the program holding his/her interest, is it appropriate for his/her age range, and does the student feel she/he is learning anything from it. Only students can provide answers to these last questions. (p. 16)

Similar insights had been offered years earlier by Hall (1978), who asserted that "For CBE applications, particular attention should be paid to the implicit decisions and alternatives from studies of individual learners" (p. 88).

The third assumption of the naturalistic paradigm—"that generalizations are not possible, that at best what one can hope for are 'working hypotheses' that relate to a particular context" (Guba, 1981, p. 77)—is
reflected in Hall's (1978) call for a focus on individual learners and in the work of Cohen and the Della-Pianas as well. Della-Piana and Della-Piana (1982), for example, cited the strengths of case study methodology while at the same time deferring the question of generalization to a point well beyond the scope of the individual research effort:

Any reasonably permanent set of criteria for courseware criticism must derive from the experience of application to many instructional packages in many subject domains. It is only upon the base of numerous case studies that critical criteria and procedures may be refined and primarily then that it would be useful to judge the criteria and procedures against critical competitors. (p. 4)

Cohen (1983b) also espoused this view. Calling for trials of courseware with many students, she asserted:

By combining these separate pieces of information an educator will have a solid basis to try to determine if the program will, in fact, be instructionally effective in a classroom. (p. 16)

It is important to note that the authors discussed above set out not to extol the values of naturalistic inquiry but to suggest the best way to meet an urgent need in the field of CBE research--the need to develop a more thorough and more detailed understanding of how and why courseware does and does not work with the students for whom it has been designed. Despite ample evidence of the general effectiveness of CBE and widespread interest in the
particular dimensions contributing to this effectiveness (see Chapter II), it is still the case that the ways in which the instructional dimensions of courseware actually "work" in daily instruction have remained, for the most part, a mystery; the specifics of the relationships of the various manifestations of the dimensions to individual learning tasks encountered in classrooms every day are still largely unknown. As Kearsley, Hunter, and Seidel (1983) pointed out:

Despite two decades of research in CBI [computer based instruction], we know relatively little about how to individualize instruction. . . . many of the individualization strategies commonly employed in CBI courseware (e.g., pretests, difficulty levels, remedial sequences) are crude in nature. CBI has thus far been able to demonstrate the potential of individualized instruction, but we have not advanced very far in achieving it in a sophisticated fashion.

Similarly, we do not understand much about the effects of major instructional variables underlying CBI. For example, we know that graphics is [sic] very important in most kinds of CBI applications, and many arguments have been advanced for the use of graphics. Yet we must rely on intuitive guidelines regarding their use: we do not know exactly what contributions they make to the learning process and, hence, how to use them in a precise and predictable way. This is also true of variables such as speech or audio (e.g., narration), dynamic sequences (i.e., animation or video), and humor. Most fundamentally, we do not know a great deal about interaction. Generally, the more interaction (and, hence, student involvement), the better the quality of the CBI. However, sometimes the interaction is trivial in nature, as in the case of CAI [computer assisted instruction] lessons which require the student to constantly "parrot" back information presented on a previous screen.
One of the few CBI variables we do understand well is feedback, thanks to the legacy of reinforcement theory. Ironically, feedback sequences in CBI are frequently poor due to the lack of knowledge of this body of research on the part of courseware developers. (p. 94)

Thus, although Hall (1978), Cohen (1983b), and the Della-Pianas (1982) have reflected the assumptions of the naturalistic paradigm and supported the use of qualitative techniques, it was the anticipated results of case study research rather than a commitment to this methodology that led them to suggest this approach. Della-Piana and Della-Piana (1982), for example, arguing that the case study is the best method for discovering the details of the particular ways in which the instructional dimensions of courseware can and do enhance learning, pointed out the potential of this methodology for leading to guidelines for designing effective CBE instruction for a variety of learners:

The perhaps most valuable data set against which all others may be usefully juxtaposed is a detailed description of the cognitive processes of the student working through an instructional sequence. . . . This kind of information has immediate practical utility for diagnosis or adaptation of instruction to individual differences as well as long-range utility for generating significant instructional prescriptions. (p. 4)

If the detailed information required to generate such prescriptions for students at large is, at present, lacking, the situation is even more complex for students
with learning disabilities (cf. Hanley, 1984). Many authors cited in Chapter II have discussed the difficulty of determining what is and is not effective for such a heterogeneous population (see especially Senf, 1983; Berkell, 1984; Weisgerber, 1984; and Hoffman, 1985). Within any given group of learning disabled (LD) students, the researcher is likely to find a host of "multiple realities" that underscore the importance of examining the instructional dimensions of courseware in context rather than as separate, manipulable variables. Some LD students, for example, have difficulty processing verbal information; some cannot master simple arithmetic computation; and some have weaknesses in coping with spatial relationships that make even the simplest motor tasks (like tying shoes) seem unconquerable. When one considers further the variety of manifestations of each of these three general types of disability (verbal, computational, and spatial) one can understand the necessity for conducting research that takes all these perspectives into account. Similarly, one can see the importance of arriving at particularistic, highly individualistic "truth statements" rather than generalizations based upon a norm. And, finally, one can see that close interaction between the researcher and the subjects of research is the only way such insights can be gained.
Indeed, the history of special education itself reflects the field's tacit acknowledgment of many of the assumptions of the naturalistic paradigm in both teaching and research—the commitment to the total individualization of instruction, the use of criterion referenced rather than norm referenced measures of achievement, the emphasis on systematic observation of individual students' behaviors in single-subject designs. Because "Microcomputer education and special education share the hallmark of individualization" (Senf, 1983), a research methodology designed to highlight individual characteristics of both the instruction and the instructed seems especially appropriate.

Entailing a focus on individual students' reactions to the individual dimensions of the courseware they encounter in their ongoing, day-to-day instruction, the case study approach thus reflects the orientation of both CBE and special education toward a particularistic, context-bound view of reality. By addressing the specific ways in which individual students and their teachers interact daily with courseware in order to learn and to teach, this approach allows a researcher to concentrate on meeting the current need of both fields to develop an understanding of the unique, individual details of the "whys," "hows," and effects of various instructional dimensions of courseware
as these are actually encountered during the normal instruction of LD students. By calling for a close and detailed investigation of the relationship between each student and the instructional dimensions of courseware actually in use, the approach requires the researcher to interact closely with the subjects of the research to gather the wealth of specific information necessary for developing the deep and detailed understanding of day-to-day effectiveness that is the ultimate concern of courseware design. As Stainback and Stainback (1984) noted in their call for more qualitative research in special education, the approach offers broader possibilities as well:

The field of special education could benefit in terms of innovative ideas and theories emerging from a variety of diverse field data collected in naturalistic school settings. This could help bridge the gap between practice and theory in special education. (p. 404)

The rationale for using the naturalistic paradigm and qualitative techniques for this study thus sprang from both philosophical and practical considerations. Not only was "the phenomenon being investigated" (Guba, 1981, p. 76) best described according to naturalistic assumptions, but the state of the field suggested that its needs could best be met with the kinds of information only qualitative methodology can provide. In this instance, theory and
necessity converged to support the choice of a naturalistic approach.

Setting and Participants

The setting for the study was the Marburn Academy—a private school for LD students located in Columbus, Ohio. Founded in 1981 with 16 students, Marburn enrolled as many as 76 children at the time of the fieldwork portion of the research (the spring and fall semesters of 1984 and the first few weeks of winter 1985). Throughout this period, the school had in instructional use four Apple II microcomputers with single disk drives and color monitors; many of the students also had access to family computers at home.

A new and rapidly growing institution, Marburn reorganized during the data collection effort to accommodate an increasing number of pupils and a maturing student population. Thus, between the spring and fall phases of the study, the school evolved from two divisions (elementary and middle school) into three (lower, middle, and upper) and hired several new teachers to serve a near-25% increase in its student population. One result of these changes was that most of the middle school students and teachers involved during the spring constituted the newly created upper division in the fall and winter. In
addition, the new middle division was composed primarily of new students and instructed by two newly hired teachers.

To ensure continuity of participants, students and teachers from the spring group were retained in the subject pool in the fall and winter; to ensure continuity of focus on the selected age group, students and teachers in the new middle division were added to the pool. Table 1, "Participants in the Study," shows that a total of 62 students (46 boys and 16 girls) and seven teachers from five subject matter areas participated in the two segments of the study. In the table, Phase 1 refers to the spring segment and Phase 2, to the fall/winter segment. Middle division students ranged from 9 to 14 years of age with modal ages of 10 and 11 (6 at each age) while upper division students ranged from 11 to 18 with a modal age of 15 (15 students). Three students—a boy in the upper division and a boy and a girl in the middle division—were black, and all other study participants were white.

Entry

Marburn was eager to be involved in the research. Convinced both that CBE holds great promise for his students and that considerably more knowledge is necessary to bring that promise to fruition, the school headmaster responded to a telephone inquiry about the possibility of
Table 1
Participants in the Study

<table>
<thead>
<tr>
<th></th>
<th>Students</th>
<th>Teachers</th>
<th>Subject Matter Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Total</td>
</tr>
<tr>
<td>Middle division</td>
<td>12</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Language arts, math, science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper division</td>
<td>22</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>(Phase 1)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper division</td>
<td>12</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>(Phase 2)+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td>46</td>
<td>16</td>
<td>62</td>
</tr>
</tbody>
</table>

*Includes one teacher/administrator who was not teaching regularly at the time but who was interviewed about previous experience with CBE at the site.

+New participants only; 15 students (11 boys and 4 girls) and 3 of the 5 teachers from the Phase 1 group also participated.
using the school as a research site by granting his permission immediately and by arranging an appointment with the researcher only two days later to discuss the school and the details of the proposed research.

In preparation for that meeting, letters informing parents/guardians and teachers of the nature, purpose, and procedures of the study were prepared (see Appendix A). These letters stressed that subjects' involvement would be voluntary; that all sources of information gained through the study would remain anonymous; and that little, if any, discomfort should accrue to participants. The letters were submitted along with the appropriate consent forms (see Appendix A) to gain clearance for the study from the University's Human Subjects Review Committee. Once clearance had been received (see Appendix A), the materials were sent to the parents/guardians of prospective participants by the headmaster—accompanied by his own cover letter describing the significance of the study and his desire to have Marburn be the research site.

Data collection began on April 16, 1984, when a sufficient number of consent forms had been returned to allow the research to proceed. A total of 27 consent forms are on file at Marburn and in the researcher's archives for students who were involved in the study during the remaining weeks of the spring semester. The absence of
forms meant that three middle school students did not participate in this initial phase of the study.

Because a smaller number of middle school students than Marburn had expected were actually enrolled in the school's summer program, the researcher was unable to conduct observations during that period, as originally planned. Anticipating the resumption of this activity in the fall, Marburn enclosed the letters and consent forms for the study with the information packets routinely sent to the parents/guardians of all students over the summer. As a result of this mailing, consent forms for 17 new students in the school’s middle and upper divisions were received by the beginning of the school year. When forms for only 4 more students trickled in during the first weeks of school, a follow-up letter was sent to parents/guardians in October (see Appendix A). This letter and some reassurance to a few parents provided by teachers yielded 10 more forms; 6 additional forms were returned as new students enrolled at Marburn during the course of the fieldwork.

Consent forms were thus returned for all new prospective participants for the second phase of the study. Since only one nonparticipating student remained at the school from the spring group, virtually all the middle and
upper division students were in the subject pool for the fall and winter phase of the research.

At the inceptions of both the spring and fall/winter phases, Marburn allocated time during scheduled faculty meetings to allow the researcher to explain the nature, purpose, and procedures of the study; to gain faculty consent to participate; and to address teachers' questions and concerns about the study and their involvement in it. Informal conversations throughout the data collection effort (which concluded January 16, 1985) also provided opportunities to clarify issues that emerged as the study progressed.

Data Collection

As part of a general attempt to ensure the trustworthiness of the research, triangulation (Guba, 1981) was employed in the selection of overlapping data collection methods for the study. Three techniques traditionally associated with the qualitative, or naturalistic, approach—prolonged and persistent observation, informal interviewing, and the analysis of relevant documents—were chosen to augment the credibility, transferability, dependability, and confirmability of the study's findings (see Guba, 1981, pp. 83-88).
Observation

Prolonged and persistent observation was employed to ensure the credibility of the findings. During both phases of the research, 63 sessions spread throughout 21 weeks were spent observing computer usage at Marburn; the modal number of weekly sessions was three. A total of 70.26 hours was spent observing students and teachers actually using the microcomputers for instruction in whatever subject matter areas were normally taught, while additional hours were spent observing introductory and follow-up activities related to computer use. Two teacher introductions—one to the computer in general and one to a particular instructional package—were audiotaped as well as observed.

The observations involved 26 commercial courseware packages and took place in five locations—the upper division language arts, mathematics, and social studies rooms; the computer area serving the middle division for mathematics, science, and language arts; and the learning center/computer room adjacent to the school library. Although attempts were made to ensure that no individual location was overemphasized and that the total amount of observation time did not become a burden on any participants, a substantial majority of the subjects' and the researcher's time was devoted to math drill and
practice courseware—a situation that reflects the generally predominant use of this kind of courseware throughout the field of CBE.

At the beginning of the observation phase, the general purpose of the study—that is, to investigate the ways students interact with courseware—was briefly explained to the students by either the teachers or the researcher. Strong emphasis was placed on the fact that the courseware—not any student—was to be the focus of the data collected by the researcher as she sat near individual students and took notes on their interactions with the computer. For the first few weeks of the study, the observations themselves were informal and unstructured in order to allow the researcher to obtain an overview of the school, to establish herself as an accepted member of the setting, and to allow her to gather preliminary data on which of the instructional dimensions outlined in Chapter I seemed most and least promising to investigate. During this period, for example, it became clear that the scarcity of tutorials and simulations in use at the site would make a detailed study of concept development impossible.

As the fieldwork progressed, the observations remained informal but were focused increasingly on the dimensions that seemed most salient in the research setting. Questions to students and teachers about their interactions
with the courseware were incorporated into the observation sessions as a means of confirming or denying the accuracy of the researcher's observations. The questions thus served as informal member checks employed throughout the observation period.

**Interviewing**

Participants were interviewed toward the middle and end of the overall data collection period; a total of 19 audiotaped interviews, most lasting approximately 45 minutes, were conducted. The headmaster, the six participating teachers, and one teacher/administrator were interviewed individually; one teacher who participated during both the spring and the fall/winter segments of the fieldwork was interviewed at the conclusion of each phase. Ten small groups of students were interviewed, five in each of the two data collection phases, during regular class times; all participating students who were in school when their classes were interviewed attended the interview sessions.

Individual interviews with adult participants enabled the researcher to explore each of their particular perspectives in depth, while group interviews with students enabled her to elicit the opinions of all available students (rather than a select few) in a forum in which the
students could build upon one another's viewpoints to clarify their own. Collecting information from all these different kinds of participants is another example of the triangulation efforts made to ensure the credibility and confirmability of the research.

The interviews were unstructured and guided by informal interview schedules (i.e., lists of questions and probes for use in following up those questions) developed as the observations progressed. The schedule for the headmaster was designed to obtain information about the administrative context of the research setting, while the schedules for the other interviewees were designed to focus more directly on courseware. Interviewees were also invited to suggest and comment upon additional issues they believed should be addressed in the final report.

Document Analysis

Attempts were made to corroborate and enrich the information gleaned through the two primary data collection techniques (observations and interviews) through the examination of a variety of artifacts related to the study: the courseware itself, its accompanying documentation, a number of materials (such as schedules) produced by Marburn, and participating students' records. Although clearly secondary in focus and significance, this document
analysis was performed to deepen and clarify emerging insights into the instructional uses of CBE with LD middle school students. The document analysis also yielded "referential adequacy materials"—that is, "'raw' . . . data items . . . against which findings and interpretations can later be tested" (Guba, 1981, p. 85) to determine their credibility.

Data Analysis

As explained in detail by Schatzman and Strauss (1973), Bogdan and Biklen (1982), and Miles and Huberman (1984b), qualitative data analysis begins during data collection and extends beyond it until the results of the research are finally reported. Accordingly, the analysis of the data for this study commenced early in the fieldwork and continued throughout the investigation.

During Data Collection

After each observation session, raw notes taken at the setting were expanded into extensive interpretive fieldnotes that served both to refine and direct the focus of the continuing fieldwork and to provide the basis for the final data analysis. As explained by Bogdan and Biklen (1982), this continuous interaction between collecting information and reflecting upon it was the first step in
the data analysis, since it was the procedure through which informed decisions were made about the most profitable foci for further investigation.

These expanded fieldnotes contained a variety of descriptive data—portraits of the site and the participants, depictions of specific facets of courseware packages, and accounts of teachers' implementations and students' interactions—as well as interpretive information—the researcher's explications of these phenomena, recommendations related to courseware improvement, and notes about methodological considerations and concerns. In an effort to distinguish the two kinds of information included in the fieldnotes, observations were typed without special punctuation, while the researcher's reflections were enclosed in brackets.

By the end of the data collection effort, the expanded fieldnotes included some 500 pages of descriptive and interpretive information. This sheer amount constitutes the "'thick' descriptive data" Guba (1981) believes is necessary to "permit comparison of this context to other possible contexts" (p. 86) and thus to guard against situational uniqueness and enhance transferability. Moreover, the fieldnotes, along with other materials accumulated during the research, provide an "audit trail" that could be used by an external auditor to assess both
the dependability of the research process and the confirmability of its findings.

Examinations of the developing fieldnotes yielded the topics for the questions and probes incorporated into the interview schedules for all participants. Designed to expand upon or clarify issues and questions raised during the observations and to confirm or deny tentative conclusions reached by the researcher, the schedules were used for member checks as well as data collection.

Appendix B provides samples of the questions and probes used on the schedules. The items listed for all the schedules are composites reflecting the types of information sought rather than a verbatim record of questions asked. The items for the teachers, for example, include a core of topics addressed in all teacher interviews as well as expansions of that core that address points especially significant for particular respondents.

The diversity of the interviewees allowed the researcher to "maximize the range of information covered" (Guba, 1981, p. 86)—the function of the theoretical/purposive sampling Guba prescribed as a method for enhancing the transferability of qualitative findings. In particular, the different perspectives among the teachers, ages among the students, and observed experiences with both types of participants were excellent sources of a wide
variety of information and insights.

Tapes of the interviews were transcribed by an experienced free-lancer employed by the researcher and instructed briefly by her about the particular demands of this study (e.g., the need to capture verbatim the "kidspeak" included on the tapes). All 250 pages of transcripts were verified against the tapes, annotated with the researcher's insights, and joined with the fieldnotes to serve as the basis for the final data analysis. The tapes and the transcripts also provide referential adequacy materials to buttress the credibility of the study.

Notes taken during document analysis were also incorporated into the growing body of source material for the study's final data analysis. Of particular importance here was the information gleaned from a painstaking examination of the courseware itself—a process that involved sketching and otherwise documenting key displays as well as repeated passes through all the programs to ensure the reliability of the researcher's insights into their manifestations of the instructional dimensions under consideration.

After Data Collection

Final data analysis began after the fieldwork for the study had been completed and consisted initially of
examining and sifting all the fieldnotes to develop coding categories (see Appendix C) that reflect not only the general questions and specific foci delineated in the research questions but also a number of other dimensions that emerged during data collection as particularly significant. After the fieldnotes, interview transcripts, and relevant documents had been coded according to these categories and attempts to transfer the fieldnotes to the University's mainframe computer for an initial sort into the categories proved unsuccessful, copies of all the materials were sorted by hand into file folders labeled with the coding categories. The context of each coded item was maintained through the use of a secondary system of codes identifying the source of the information—for example, the number of the observation session recorded in the fieldnotes. This secondary system allowed efficient access to the original, unsorted copies of the documents.

The next step in the final data analysis involved developing an organizational scheme by which the wealth of information described above could be analyzed, synthesized, and presented in an efficient and effective manner. This was a four-stage process, beginning with the creation of a series of working matrices and culminating in the creation of the tables that present the findings of the study in Chapters IV and V. Samples of the three preliminary
documents—on which the names have been changed to ensure the anonymity of study participants—are contained in Appendix D, while the process itself is described below.

Following the guidelines offered by Miles and Huberman (1984b) the researcher first developed a series of matrices related to the three broad areas of the study findings—teachers' perceptions and behaviors, students' perceptions and behaviors, and effectiveness as perceived by both teachers and students—to serve as basic tools for the final data analysis. Specific topics for the matrices reflected both the original research questions and other areas that emerged during the study as natural extensions and amplifications of findings related to those questions: one matrix was developed to collect information about teachers' perceptions of effectiveness, for example, while another was created to capture the researcher's recommendations based upon the fieldwork. In general, data cells were formed by the intersections of (a) particular types of information related to the general topics with (b) the sources of that information. Data cell entries came from the coded fieldnotes, interview transcripts, and other documents described above.

The actual compilation of the matrices began after this data—arranged thematically in the file folders, as described above—had been sorted according to participant
to enable the researcher to determine which items were relevant to the greatest number of participants and were therefore of particular significance. This sort involved aggregating the coded information within and across relevant coding categories through the creation of a variation of what Miles and Huberman (1984b) call meta-matrices (or "monster-dogs") and define as "master charts assembling descriptive data from each of several sites in a standard format" (p. 152). Although these authors envisioned meta-matrices as charts posted on large sheets of paper and showing relevant data for each of several sites, the meta-matrices for this study were actually narrative, developed with the assistance of the "search" function of a word processing package that enabled the researcher to compile the information for each participant more efficiently at the computer than by hand. The narrative meta-matrices were subsequently converted by hand into chart matrices that still linked data to individual participants but that described that data in condensed form. Finally, the information from these charts was aggregated under descriptive labels (e.g., "general reading difficulties") and instances related to each were counted in order to compile the tables in Chapters IV and V.

The narrative accompanying the tables describes the most significant patterns, the most critical insights, and
the most telling illustrations related to each. In particular, the narrative brings out individual perceptions and behaviors that tend to be subsumed in the tables, which are based upon frequency counts. The concluding section of each chapter further explores themes and patterns related to general issues involved in the sound design and effective use of CBE courseware with students like those involved in the study.

Peer reviews were accomplished in two stages—the first after Chapters I, II, and III had been written and the second upon the completion of Chapters IV, V, and VI. Four of the researcher's colleagues—two experts in CBE, one expert in qualitative methodology, and one expert in instructional systems design—served as peer reviewers and read and commented upon the entire report.

Informal member checks were conducted throughout the fieldwork, and formal ones were completed after the study findings had been developed as Chapters IV, V, and VI. Three of the teachers involved in the study—two consistent/experienced users and one exploratory user/novice—read and commented upon these chapters and reported them interesting, informative, and—most importantly—credible. All three teachers thought the findings "useful to me as a classroom teacher" and wanted to keep copies of the chapters for their personal use.
Several features make the Marburn Academy unique in the field of learning disabilities. The only private school for learning disabled (LD) students in the Midwest, Marburn enrolls or has enrolled students from Indiana, Illinois, a half-dozen communities scattered throughout Ohio, and over a dozen school districts within the Columbus metropolitan area. An expensive (but nonprofit) institution—1984/85 tuition was $6,000—it offers some scholarship aid and is underwritten by Federal laws stipulating that all educational costs for children diagnosed as LD may qualify as tax deductible medical expenses. A new and relatively small enterprise—begun in 1981 and currently enrolling fewer than 100 students—it conducts several funded research efforts within the school and houses the Midwest Foundation for Learning Disabilities, an outreach mechanism serving a broad constituency of individuals concerned about learning disabilities. A racially and economically homogeneous setting, it has a faculty/staff that is all white except for one Hispanic teacher and a student body that contains
only a handful of blacks, no other minorities, and comparatively few students who do not appear to be from comfortable or even affluent families.

An awareness of this general background and of the more specific, day-to-day context in which this study took place is critical to the understanding and utilization of the research findings presented in this report. This chapter, therefore, begins by describing the immediate context of the study and then presents findings related to teachers' perceptions and uses of computer based education (CBE) and CBE courseware within the Marburn environment.

The Marburn Environment

A newly painted sign atop a small knoll near the main entrance announces that the modern, one-story building is the Marburn Academy. Five acres of gentle landscaping set off the square, red-brown tiles of the school's facade and provide ample space for a sports field and a playground for the students. The campus blends comfortably with the expensive two-story homes and wide, carefully tended lots of the mid-1970s residential development that surrounds it.

Inside, the building is bright and spacious. Designed during the heyday of the open-school concept, the facility is comprised primarily of large areas that can be subdivided into smaller ones by folding walls. Most of
these areas are carpeted in a neutral shade, and the halls and walkways that connect them are covered with light beige tile. Although the school's floor-to-ceiling windows are relatively few in number, walls are lightened with gold or chartreuse paint or with beige grasscloth. Large painted numerals designate the different classrooms; large painted stylized symbols designate the unnumbered rooms—restrooms, multipurpose room, janitor's closet. Built-in cabinets and counters in every classroom (including the science laboratory) and shoulder-high shelves demarcating the boundaries of the library offer easy storage for the full spectrum of instructional resources. An abundance of teacher- and student-made decorations on walls and bulletin boards adds color, warmth, and humor to the surroundings: "The beef is in the books at Marburn Academy" proclaims a large sign that brings a currently popular advertising slogan to the school library.

The architectural informality of the campus is echoed in the dress of the campus community. Adults wear clothes that range from bowling shirts and Bermuda shorts to suits and jacket dresses but that generally cluster around casual, contemporary styles—crewneck sweaters, skirts, comfortable slacks. Students, with some exceptions, wear the accepted uniforms of their generation—jeans, cords, a variety of casual tops (often advertising rock groups or
"in" designers), sweatsuits, and the ever-present backpacks and running shoes. During the course of the study, some of the more fashionable students appeared wearing nylon "parachute pants" with innumerable zippered pockets; skinny white or black leather ties; clear plastic "jelly" shoes; Army fatigues; and a variety of "accent pieces"—such as a neon green net scarf tied around a blue-jeaned thigh.

The atmosphere, too, is informal, friendly, and supportive. The student body is small, and staff seem to know all the children by name. Student-staff exchanges are marked by a level of courtesy that is surprising to a newcomer: "Tie your shoes," calls a staff member to a student hurrying past, adding "Thank you" when the boy immediately stops and complies. "You're welcome," replies the student—without a trace of often-predictable adolescent irony. In keeping with standard special education practice, teachers praise every student accomplishment, no matter how small: "I'm real proud of you, _____," soothes a teacher to a timid little girl who simply could not work a CBE math program when she forgot how to divide; "you didn't cry or anything." Teachers also work to ensure that their students—whose categorization as learning disabled testifies to a history of academic failure—have successful academic experiences here: in response to a boy's announcement that "My time's up" when
his difficulty with a program has made him exceed his assigned time period, a teacher gently laughs, "Oh, your time's 'way up; do one more." She stands nearby as he works one last problem, ensuring that his final computer experience of the day will be positive.

Students seem to have internalized the faculty's nurturing approach: "_____ did it! _____ did it!" call out several students when a classmate is the first to solve a computer mystery game. They clap for him and gently cuff him, showing genuine pleasure at his accomplishment. "Can you read that?" asks another boy, concerned that a classmate is at a disadvantage in another game that the questioner himself is anxious to win. Of course, there are also instances of students' losing their tempers, arguing over whose turn it is, teasing about boyfriends and girlfriends, raiding each other's lunches, and generally testing behavioral limits; but the examples cited above suggest that acceptance and encouragement are major characteristics of the Marburn atmosphere.

If the surface ambiance at Marburn is casual, the underlying purpose is not. Everyone at the school is clearly aware that the institution exists for students with special needs; and the philosophy, organization, and staffing suggest that strong and considered attention is given to meeting those needs. Philosophically, the school
curriculum is grounded in a "developmental model based on Piagetian and Eriksonian theories" (Leclair, 1984). Although such behavioristic techniques as time-outs, rewards, and contingency management are evident in daily practice, these are employed in the service of advancing the integrated cognitive, emotional, and social development of each student.

The school is organized into three divisions (lower, middle, and upper) and six major departments (language arts, math, social studies, career exploration, science, and art/drama/music/physical education). Equipment is sophisticated and up-to-date: in addition to the four computers that provided the focus for this study, students have access to such tools as VCR-equipped television sets and tape recorders stocked with tapes of textbook material. Classes are small--limited, in most cases, to seven or eight children--and student placement reflects students' maturity levels in each of the three developmental areas noted above. New classes are formed when a sufficient number of new students at a particular level have been accepted: "If I have five kids who want to come," explains the headmaster, "I hire a teacher."

The instructional day consists of seven 45-minute periods, each characterized by a great deal of personal attention to the individualized programs designed for each
student. Students keep track of their activities in special plan books they take to each of their classes during the day and home with them after school. Teachers confer freely with each other about student successes and problems, and each homeroom teacher is in weekly contact with the parent(s) or guardian(s) of his/her homeroom students to report on the full range of individual students' accomplishments (or lack thereof) during the week.

In addition to academic staff who support the subject matter areas noted above, Marburn employs a reading specialist and a speech therapist and retains a psychologist as well. Administrators—the headmaster, the program director, and the development director—and secretarial and custodial personnel round out the Marburn staff. A variety of extracurricular activities—basketball and soccer teams, a cheerleading squad, an annual play, a yearbook, and a newspaper—round out a comprehensive program designed to provide experiences for Marburn students that are often unattainable by LD students in other settings.

Computer Use at Marburn: An Overview

The impetus for computer use at Marburn comes directly and persistently from the headmaster. This slightly built
man with bluish eyes and graying hair presents a calm exterior that belies an intensity of purpose and a strong commitment to "my school," "my program," and "my kids." Obviously proud of his recognition almost 20 years ago that "learning disabled kids seemed to have . . . a natural affinity for computers," he speaks of Marburn as a pioneer in using computers with LD students. Indeed, he "insisted on the computers [as] one of the conditions of his coming to Marburn" (Lease, 1983) in the summer of 1982, a year after the school opened. Since then, he has instituted a required course in LOGO (now discontinued), introduced word processing to the language arts program, and encouraged teachers at all levels and in almost all subject matter areas to use computers with their students. It is he who orders courseware packages for preview (generally on his own initiative but also with input from others) and who distributes these to the faculty he believes should try them. Although experience with available materials has tempered his enthusiasm for CBE, he continues to hope in the potential of this technology for his constituents; to believe that courseware can and should be better; and to be pleased that no one else in the country has examined courseware in the way that this study--conducted in his school--has done.
Under the headmaster's guidance, Marburn has purchased a number of courseware packages, including many of the "standard" pieces. A review of the school's collection early in the fieldwork revealed a variety of MECC (Minnesota Educational Computing Consortium) and other overtly instructional materials as well as such familiar "educational" packages as Snooper Troops, Gertrude's Puzzles, Moptown Parade, The Factory, Rocky's Boots, and several issues of Scholastic's Microzine. Some of these—as well as other packages either found in the collection at the outset of the research or brought in during its course—were used by the participants in the study; others, both in the collection and brought in for preview, were never seen in use.

Computer Use by Marburn Teachers

Tables 2 through 6 display various facets of Marburn teachers' perceptions and uses of CBE during the fieldwork: the academic and personal/social outcomes of computer usage, the courseware selected and rejected, the logistics of implementing CBE in the classroom, and the instructional strategies employed to enhance the value of CBE for students. When reviewing these tables, it is important to understand that they—and all the other tables in this document that present teacher data—were developed
according to certain specific procedures and criteria. The explanatory narrative that accompanies the tables also reflects these decision rules.

First, teachers were grouped in the tables according to the researcher's observations of their frequency of use of courseware and according to self-reports or the researcher's conclusions about their degree of experience with CBE. Teachers in the "consistent users/experienced" group had used CBE prior to the study and, during the fieldwork, were observed to use the computer comfortably and regularly and to integrate computer experiences into ongoing classroom instruction with ease. Teachers in the "exploratory users/novices" group had had little or no prior experience with CBE; were neutral, hesitant, or even negative about computer use in the classroom; and seemed to use courseware during the study primarily at the urging of the headmaster and/or to accommodate the researcher. Teachers in the middle group--designated "sporadic users/experienced"--had used computers prior to the study but for various reasons (e.g., lack of ready access to hardware, reassignment to new duties) were observed using CBE only rarely during the fieldwork.

Second, because each segment of these tables deals with the responses of a single individual, perceptions and behaviors were included irrespective of their replication
by other participants. Thus, the criterion of confirmability—a critical one in qualitative research (Guba, 1981) and the hallmark of the tables in this document reporting student data—was suspended for these tables in the interest of reporting as fully as possible the findings about this diverse group. Because the headmaster is such a force in computer use at Marburn, his perceptions—which often reinforce those of the teachers—are also included in these tables as appropriate.

And third, teachers were not identified by division or subject matter area in the tables in order to protect their anonymity. One aspect of teacher identity, however, is important to disclose because it relates to a significant pattern that emerged during the study: both teachers in the "consistent users/experienced" group are math teachers who had access to computers housed in their rooms; by contrast, both language arts teachers in the study—who also had computers in their rooms for most or all of the research period—belong to the "exploratory users/novices" group. This split, as well as reasons for it discussed with the appropriate participants, suggests a confirmation of a condition long lamented by observers in the field: most computer-assisted instruction in schools occurs in math, and little occurs in language arts. This situation, particularly as it affects LD students, has serious
implications for courseware design for this population. These and other implications of the teachers' interactions with CBE are discussed in the final section of the chapter.

**Perceived Effectiveness of CBE**

Table 2, "Teachers' Perceptions of Effectiveness," displays participating teachers' views of the positive, neutral, and negative aspects of CBE in the academic and personal/social realms. Included here primarily to provide some perspective on teachers' uses of courseware, the table summarizes a variety of information about participating teachers' views.

Most teachers agreed that students are more stimulated, more involved, and more on-task while working on the computer than in other settings. Interestingly, however, teachers frequently ascribed the motivational strength of CBE to factors quite outside the graphics and interactivity usually associated with motivation in the literature: in the view of several teachers--including both of the consistent/experienced ones--the computer is effective in holding students' attention primarily because it removes them from the distractions of classroom flow. "They're definitely more at task on the computer," claimed Teacher B:
Table 2

Teachers’ Perceptions of Effectiveness

<table>
<thead>
<tr>
<th>TEACHERS</th>
<th>Academic</th>
<th>Personal/social</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistent users/experienced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher A</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>helps increase speed on timed tests</td>
<td>builds self-confidence</td>
</tr>
<tr>
<td></td>
<td>keeps students on task longer</td>
<td>helps them work better in a group</td>
</tr>
<tr>
<td></td>
<td>promotes transfer (minimal)</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>removes students from disruptions of classroom flow</td>
<td>usually one student does all the work</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>not motivating in itself</td>
<td>helps them feel successful (if assigned properly)</td>
</tr>
<tr>
<td>Teacher B</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>keeps students on task (because they’re alone)</td>
<td>helps them feel successful</td>
</tr>
<tr>
<td></td>
<td>promotes transfer (visual cuing)</td>
<td>(if assigned properly)</td>
</tr>
<tr>
<td></td>
<td>tactile (touching keys)</td>
<td>makes them want to try new things</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>doesn’t always promote transfer</td>
<td>doesn’t always promote transfer</td>
</tr>
<tr>
<td></td>
<td>allows students just to stare when tired</td>
<td>allows students just to stare when tired</td>
</tr>
</tbody>
</table>

Sporadic users/experienced

Teacher C | Positive |
<p>| | sometimes more successful than self |
| | (some students, some skills) |
| | keeps students more on task |
| | may motivate some not typically motivated |
| | forces interaction, correction |</p>
<table>
<thead>
<tr>
<th>TEACHERS</th>
<th>Academic</th>
<th>Personal/social</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher D</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>more successful than textbooks</td>
<td>helps them learn to agree, to share</td>
</tr>
<tr>
<td></td>
<td>because of novelty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>opens students to lessons because</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of their computer expertise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>task is the same</td>
<td></td>
</tr>
<tr>
<td></td>
<td>other tools are as good</td>
<td></td>
</tr>
<tr>
<td></td>
<td>not motivating in itself</td>
<td></td>
</tr>
<tr>
<td>Exploratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>users/novices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher E</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>holds students' attention</td>
<td>makes them feel safe</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>easier for some students to</td>
</tr>
<tr>
<td></td>
<td>may help learning, may not</td>
<td>relate (nonjudgmental)</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td></td>
</tr>
<tr>
<td></td>
<td>allows students to waste time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>removes students from teacher's aid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>confuses students about where they are when they rejoin class</td>
<td></td>
</tr>
<tr>
<td></td>
<td>no evidence of transfer</td>
<td></td>
</tr>
<tr>
<td>Teacher F</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>cuts out distractions</td>
<td>increases abilities to work</td>
</tr>
<tr>
<td></td>
<td>motivating</td>
<td>independently</td>
</tr>
<tr>
<td>Teacher G</td>
<td>Positive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>involves students</td>
<td></td>
</tr>
<tr>
<td></td>
<td>provides constant stimulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>adds to quality of classroom work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>does no more than worksheets</td>
<td></td>
</tr>
</tbody>
</table>
Why? Because they're alone. . . . They’re not going to get anyone else looking at them. If someone else drops a pencil, they don’t see it. . . . [In class] they have to filter out who’s sitting next to them. I’m talking and walking around the room. [At the computer] there’s not that pressure.

"I really don’t think just the fact that it’s on the computer is motivational at all," explained Teacher A. "As long as they’re secluded and there’s not a whole lot there to distract their attention . . . they do a little bit better job." Both this teacher and Teacher C—who cited the novelty of CBE as its primary motivational asset—concurred that the level of students’ involvement was no greater at the computer than with a worksheet or workbook. Teacher G, comparing the effectiveness of a drill and practice program with other classroom work, asserted that "I couldn’t say it would do much more than [an analogous task] on a worksheet."

Most teachers did, however, believe the computer helped students learn—"Yes, it does," affirmed Teacher B. "It’s a very helpful tool"—and cited examples to support that belief. Teacher A, for example, volunteered that the kids are getting much better. . . . They used to take the same timed test for maybe a week before they’d finally pass it. They are passing it after the first time or the second time. . . . I ask them to practice flash cards at home and they don’t. The only time they’re doing it is on the computer and the games that they play. And that’s it. So it has to be doing something!
Teacher C reported that some students seemed to be "gaining some skills on the computer that I was not able to get them to learn in the conventional means," while Teacher D expressed a belief that students' familiarity with the computer and skill in dealing with it make them "more open to the teaching concept that's to be offered in that particular lesson" and thus enhance their learning.

Teacher F—a novice user eager to become more proficient in the area—talked about the computer as an excellent tool for some students, especially those so sure that anything they do will be wrong that they refuse to write anything down. Teacher G—another novice—asserted, "I think it really adds to the quality of what we're doing in that classroom."

Only Teacher E—also a novice—was truly skeptical:

There may be benefits but I'm not able to know for sure what they are. There are other things I can do where I know there are benefits—where I can see the results—and those I'm sure are good learning situations. The computer to me is something where maybe they're learning, maybe they're not.

This teacher, too, cited reasons for this position: "They don't know where they are when they come back to class.

... I'm not there to help them when they have a problem. Sometimes I suspect they just go and sit there and waste a lot of time." Although some of this teacher's qualms might be alleviated through more experience with CBE, the
strength of the objections expressed suggests that such experience may never be sought.

Teachers were hesitant to praise the computer as an agent in students' personal/social development except in the area of increased self-confidence. Teacher A, for example, when asked about the development of leadership skills, replied,

I don't know that I've really seen [that]. I think it probably helps them to feel good about themselves because that's a piece of equipment that's in the school that they can help out with— that they can help other kids with . . . sometimes. But that's as far as I've seen it, I think.

Teachers did seem to believe, however, that computer work had a positive effect on students' self-confidence ("Feeling good about their whole self-concept's coming out"); that it improved their group work skills ("There's no question. You have to relate, you have to get along to work one keyboard"); and that it increased their abilities to work independently ("Oh, yes. Very much so"). These statements, however, were isolated and--except for a variety of favorable remarks about self-confidence--were offered in response to questions rather than independently volunteered. Certainly, teachers' comments did not confirm either by number or intensity the claims for personal development that saturate the literature on CBE and mildly handicapped students.
In summary, Table 2 reveals that Marburn teachers have mixed feelings about the efficacy of CBE as an instructional medium: positive comments are balanced by neutral and even negative ones. In addition, many of the positive and neutral statements reflect implementation issues—particularly physical placement—rather than courseware. In any case, teachers do seem to agree that working at the computer tends to keep students on task longer—an important dimension for LD children—and that it definitely promotes self-confidence among the students. Throughout the interviews, teachers referred to the computer as a tool, suggesting a summary belief that the value of this tool—like the worth on any other—is dependent upon the skill with which it is used.

**Courseware Used**

Table 3, "Courseware Used During the Study," displays the types of courseware teachers implemented during the fieldwork; the positive features of that courseware cited by the teachers; and the reasons (other than the obvious and typical one of providing practice) teachers chose to assign students to use particular courseware packages. The packages themselves are listed in decreasing order according to frequency of use by each teacher; separate packages that form part of a series—for example, a group
Table 3
Courseware Used During the Study

<table>
<thead>
<tr>
<th>TEACHERS</th>
<th>Types Used</th>
<th>Positive Features</th>
<th>Reasons for Use*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistent users/</td>
<td>drill &amp; practice</td>
<td>record keeping</td>
<td>work on more basic or more advanced concepts than others in class</td>
</tr>
<tr>
<td>experienced</td>
<td>(&quot;workbook&quot;)</td>
<td>flexibility of assignment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td>motivational</td>
<td>as above</td>
</tr>
<tr>
<td></td>
<td>(game format)</td>
<td>saving of student work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>simulation</td>
<td>basic content</td>
<td>structure group work</td>
</tr>
<tr>
<td></td>
<td>tutorial</td>
<td>better presentation than text</td>
<td></td>
</tr>
<tr>
<td>Teacher A</td>
<td>drill &amp; practice</td>
<td>visual and tactile cuing</td>
<td>teach system, procedure</td>
</tr>
<tr>
<td></td>
<td>(&quot;workbook&quot;)</td>
<td>flexibility of assignment</td>
<td>work on more basic concepts</td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td>scope and sequence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(&quot;workbook&quot;)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td>motivational</td>
<td>provide new experiences</td>
</tr>
<tr>
<td></td>
<td>(game format)</td>
<td>visual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td>motivational</td>
<td>variety (whole class after individual)</td>
</tr>
<tr>
<td></td>
<td>(game format)</td>
<td>visual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tutorial</td>
<td>visual</td>
<td>assess abilities</td>
</tr>
<tr>
<td></td>
<td>(game format)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>simulation</td>
<td></td>
<td>one class has extra period</td>
</tr>
<tr>
<td></td>
<td>game</td>
<td>content (problem solving)</td>
<td></td>
</tr>
</tbody>
</table>

*In addition to typical use—that is, directly supplemental work.
Table 3 (cont'd.)

<table>
<thead>
<tr>
<th>TEACHERS</th>
<th>Types Used</th>
<th>Positive Features</th>
<th>Reasons for Use*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sporadic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>users/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>experienced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher C</td>
<td>drill &amp; practice</td>
<td>visual and tactile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(&quot;workbook&quot;)</td>
<td>dril &amp; practice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td>adjustability of speed</td>
<td></td>
</tr>
<tr>
<td>Teacher D</td>
<td>simulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher F</td>
<td>simulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher G</td>
<td>simulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td>must be correct before moving on</td>
<td></td>
</tr>
<tr>
<td></td>
<td>game</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>simulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>simulation</td>
<td>more interesting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td>student controlled pace</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(game format)</td>
<td>adjustability of content</td>
<td></td>
</tr>
<tr>
<td></td>
<td>simulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>drill &amp; practice</td>
<td>adjustability of content</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(game format)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*In addition to typical use—that is, directly supplemental work.
of games designed to provide drill and practice on various basic math skills—are listed as one.

Dominating the list in both number of packages and frequency of use are drill and practice (d & p) programs—another instance marking the similarity of the Marburn Academy to other institutions, all of which must contend with the fact that this type of courseware makes up the bulk of what is available for purchase today. Beyond reflecting the nature of the field, however, this pattern of usage at Marburn is also consistent with teachers' expressed beliefs in the kind of courseware that is most useful for their students: in the interviews, Teachers A, B, and D all cited d & p as preferable—Teacher A voicing a desire for materials that drill "on the process." Teacher E did not express a preference but admitted to seeing "some value in . . . developing drills that could help them remember" basic facts. Teachers F and G cited a need for d & p courseware for some students and for packages that could be used in "more creative" ways to help other students build on the basic skills they already possess.

Teacher C's insistence that courseware should provide instruction as well as d & p suggests another dimension of the question of which type of program teachers actually prefer. This teacher considered packages that require students "just [to] throw in an answer" as d & p and those
that lead the student through the process of obtaining that answer as "instructional." Thus, the teacher spoke favorably of one program as being instructional—even though it is marketed as a d & p package—because it includes some focus on process. (Interestingly, Teacher A, the teacher for whom drilling "on the process" seemed important, also spoke highly of the same program but wished it would do more in this regard.) This discrepancy in perspectives not only points up the problems in distinguishing among the types of courseware on the market but also illustrates the difficulties in drawing conclusions about teachers' actual preferences for one type over another.

Subject-matter needs and concerns also make it difficult to draw broad conclusions about teacher preferences for a specific type of courseware: two of the respondents who advocated d & p packages are math teachers, while the two who favored an additional, more open-ended approach teach less structured subjects. Perhaps most importantly, teachers' familiarity with only the limited range of courseware available to them also moderates the impression that d & p programs are in fact the most useful for Marburn's LD students: if a broader range of effective courseware were available and if the teachers were aware of that range, both their patterns of use and their beliefs
about the best kinds of courseware for their students might
be significantly different.

Although most of the courseware in use at Marburn
during this study was d & p, there is nothing inherently
present in this format—or absent from others—that
predetermines the positive features of particular
courseware packages cited by the teachers. Chief among
these advantages was flexibility: the teachers were
attracted by programs that allowed them to assign students
to specific topics within content areas and to adjust
speeds, levels of difficulty, and the content itself to
meet individual students' needs. Teacher A liked a package
in which "You can pick those things that are going along
with what . . . you are doing in class. . . . you can make
your own assignment so you can just pick out the particular
steps that you want." Teacher B praised the same package
for its scope and sequence, which facilitates making
individualized assignments for students with varying needs:
"If I'm teaching 10 kids 10 different things, hopefully
there's a nice sequence in the . . . disk that I can plug
them in--[10 children] at 10 different levels." And
Teacher G, comparing an untimed game program to a
simulation in which students worked against a clock,
reassured a class in a way that illustrates the value of
programs that include some mechanism for responding
flexibly to learning disabled (LD) students' well-known difficulties with input speed: "That's the neat thing about this program--everyone can take as long as he wants."

Teachers also praised packages that were motivational or "more interesting than the way we've been doing [a similar learning task] in our workbooks" and that reinforce students' understanding of process by showing a visual consequence of their tactile input:

I liked it because . . . you had to do something to the computer to make [the program perform a specific task]. And then you could actually . . . change [something] so that you knew what you were doing. You could visually see what you were doing.

Two packages—one on problem solving and one on very basic math facts—were considered attractive because of their content, suggesting that teachers perceive a need for materials that address learning at both ends of Bloom's (1954) continuum.

Teacher B liked several programs that are highly visual (i.e., that include strong graphic components and that support a visual learning style), while Teacher A praised a program that includes a record-keeping routine and provides an option for saving students' work "so the kid doesn't feel like what [he/she] just did was all in vain and [that he/she must] do it over again." Teacher G's explanation to an incredulous class that a program would
not save their work offers additional testimony to the importance of a "save" option for two kinds of users: teachers who choose to devote only limited amounts of class time to computer work and students whose generally slower paces often leave them unable to complete assignments as quickly as their nonhandicapped peers. As the teacher noted, the program in question was "not as useful to us as it could be."

While teachers generally chose to use courseware as a direct supplement to the lessons they were presenting in class, a number of other reasons for the use of particular programs also surfaced during the fieldwork. Not surprisingly, most of these occurred in the classrooms of the "consistent users/experienced" teachers, who were generally more sophisticated about CBE than the others. Both these teachers, for example, used courseware to provide individualized work for students who needed a little extra reinforcement or who were significantly ahead of or behind others in their classes. One upper division student, for example, worked on multiplication in class and for homework but was assigned subtraction problems on the computer; another student's use of the computer to multiply decimals addressed his needs while freeing the teacher to explain a lower-level concept to the rest of the class. A younger student who did not understand that he has 10
fingers, 5 on each hand, worked at the computer on number readiness because his needs were so far behind those of the rest of the class.

Both "consistent/experienced" teachers also saw in various programs opportunities to teach their students skills that are beyond the cognitive ones around which the programs are designed. Teacher A, for example, explained that an assignment of an entire class to work on a program together was intended to teach the students to structure their group work skills. One of the novice teachers echoed this use of CBE to enhance students' abilities to work together: "I . . . put them on there by twos because I did want them to interact," reported this teacher. "I wanted them to use the other person as a support person on the computer. And that worked real well, even with some kids that were quite different [from each other]."

Teacher B made a concerted effort to use the computer--and particularly the program this teacher used most extensively--to help students understand sequence and procedure. Foregoing an automatic routing option in the program, this teacher had each student use a sign-in sheet, find his/her assignment on another sheet, go through the program's entry sequence to get to that assignment, and record the results of his/her performance once the assignment had been completed. "I just wanted them to be
real familiar and go through steps," explained the teacher, 

[to understand] that there's a sequence. A lot 
of times they do forget things come in a 
sequence. I just wanted them to [understand] how 
you start something and then [produce] the end 
product and how to shut it off. They always have 
problems doing that. . . . They skip around . . . 
that's the LD child.

Teacher B also used various programs to encourage students 
to try new experiences; to introduce some variety in 
instruction ("to get them away from [individual work] and 
do a whole-class lesson"); to see whether a child's visual 
and spatial problems would inhibit his ability to determine 
sameness and differences; and to make use of an extra 
period to introduce an important concept: "It was more for 
problem solving. I can't seem to cover that enough . . . I 
had some extra time . . . so that's what I used that for."

In summary, one can note that the teachers who 
participated in this study used drill and practice 
courseware more than other types, cited flexibility as the 
primary positive feature of the packages they used, and 
expressed various reasons beyond the straightforward 
provision of practice for using particular packages. It is 
important to remember, however, that all these facts must 
be viewed against the background of a single, perhaps more 
significant one: like Sir Edmund Hillary, who climbed Mt. 
Everest "because it was there," the teachers primarily used 
the courseware that happened to be available to them.
Rather than independently seeking out suitable packages to meet particular objectives, the teachers for the most part implemented courseware that was already in the school's collection and had been selected or recommended by others. Thus, while the insights provided by their uses of this courseware suggest dimensions that are important for courseware designers to consider, these insights are necessarily limited by the constraints of the teachers' experiences.

**Courseware Rejected**

Just as there are no positive features inherently present in or absent from any particular type of courseware, there are no reasons for rejection restricted to particular types. Thus Table 4, "Courseware Rejected During the Study," does not pinpoint types of courseware judged unsuitable by study participants but displays reasons for the rejection of specific packages and conditions that teachers and the headmaster reported would keep them from using any package.

Several of these reasons dovetail with teachers' perceptions of positive features described above. Teacher C, for example, who believes courseware should instruct, was dissatisfied with a program that required students only to enter their final answers. Teacher D cited programs in
<table>
<thead>
<tr>
<th>TEACHERS</th>
<th>Specific Reasons</th>
<th>General Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>users/ experienced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher A</td>
<td>format too</td>
<td>financial</td>
</tr>
<tr>
<td></td>
<td>elementary</td>
<td>inappropriate</td>
</tr>
<tr>
<td>Teacher B</td>
<td>starting level too</td>
<td>limited usefulness</td>
</tr>
<tr>
<td></td>
<td>difficult</td>
<td>graphies</td>
</tr>
<tr>
<td>Sporadic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>users/ experienced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher C</td>
<td>just entering answer,</td>
<td>&quot;not worth it&quot;</td>
</tr>
<tr>
<td></td>
<td>not seeing process</td>
<td>duplicates other</td>
</tr>
<tr>
<td></td>
<td>computer functions</td>
<td>resources</td>
</tr>
<tr>
<td></td>
<td>too difficult</td>
<td>poor quality</td>
</tr>
<tr>
<td>Teacher D</td>
<td>&quot;not worth it&quot;</td>
<td>inappropriate speed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>inappropriate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>balance of words</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and graphics</td>
</tr>
<tr>
<td>Exploratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>users/ novices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher E</td>
<td>too much preparation</td>
<td>too rote</td>
</tr>
<tr>
<td>Teacher F</td>
<td>too much preparation</td>
<td>not challenging</td>
</tr>
<tr>
<td>Teacher G</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headmaster</td>
<td>too much preparation</td>
<td>extraneous</td>
</tr>
<tr>
<td></td>
<td>inappropriate content</td>
<td>no diagnostic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>feedback</td>
</tr>
</tbody>
</table>
which "the pace may be too fast for our students" as among those rejected. And Teacher G, an advocate of open-ended courseware, mentioned as a primary reason for rejection a design that is "very rote. . . . the program would present the same thing over and over again in the same format" and continued to explain that "if I saw something that I thought wouldn't be very challenging to enough of the students, I wouldn't be very interested in it."

One package, previewed during the course of the fieldwork, was returned to the publisher on grounds that echo special educators' traditional call for materials that pair lower-level concepts with graphics that are appropriate for older students. This package was examined independently by teachers in both the divisions that participated in the study and was judged too elementary in format for the upper division students who could profit from its content and too advanced in content for the middle division students who would be attracted by its particular graphics style. Although the middle division teacher felt that one program on the disk was useful, the same teacher advised that the package be returned because all its other programs were unsuitable: "I would have liked to have kept that but I could use it for [only] a week or two and then I would put it away until next year."
This theme of limited usefulness recurred several times in participants' responses to questions about what would make them reject particular courseware packages. Thus, programs that duplicate other resources or that are "nice but not necessary" would be rejected. Packages that lose their value after only a few uses would also be repudiated:

There was only one pattern. And once they discovered that pattern, they knew it. Then they enjoyed making a mistake because . . . they enjoyed [the reinforcement]. It was just a fun game--it was forget problem solving and let's just watch the [reinforcement]."

The headmaster pointed up another interesting dimension of limited usefulness when he described his dissatisfaction with "programs that don't seem to give any diagnostic feedback back to the kids or the teacher." He explained that

the problem is that if the teacher's not there watching the kid do the program, [that teacher has] no idea what . . . the kid has used to get that answer. And so you can't document it and therefore you can't take that information [and] apply it anywhere else. . . . You have no idea why [one student performed better than another]. . . . So if you can't get that kind of feedback, it's not terribly helpful.

Teachers condemned programs that are "very poorly done," including those with inappropriate reinforcers or actual programming errors; that require students (or teachers!) to perform computer functions, like setting multiple option parameters, perceived as unduly difficult;
that bombard students with distracting visual stimuli ("That was what they were looking at—all the bright colors and the lights—not really what the problem was"); and that fail to integrate graphics and text because they include "maybe too much decoration so that our students have trouble focusing in. Maybe too many words—the reverse—and not enough decorations so that we have intermittent reinforcement."

While most or all of the above reasons for rejecting courseware might have been predicted, another criterion for rejection that surfaced during the study is surprising: a surfeit of instructional design. The particular package rejected for this reason addresses daily living skills—a content area considered very important for special students—and includes many of the elements characteristic of a strong instructional package: its 117-page teacher's guide delineates objectives, includes masters for auxiliary materials, and specifies a wealth of introductory and follow-up activities to be used with the three simulations on its disk. The problem arises, however, because the package is actually an entire curriculum rather than a set of materials that can be integrated into ongoing instruction. So complete that it assumes substantial preteaching and depends upon an extensive use of its supplementary materials, the package is a well-designed,
self-contained unit whose implementation would simply
displace too much other necessary instruction. The teacher
who experimented with the package described it as requiring
too much "for what you get out of the program"; the
headmaster noted that

the program is so complicated in its initial
setup that . . . it requires a great dedication
of time. Our kids don’t learn as quickly as
other kids. So you’re going to spend maybe twice
or three times the amount of time that a
nondisabled population might need in order to get
into that program. So now you’re measuring the
value of that program against the time you’re
taking away from other activities in order to do
it . . . . you could, in fact, do something in
class—not using the computer program—at a much
reduced level in terms of its complication that
would be more appropriate for our kids. And
you’d spend less time on it.

In summary, courseware was rejected during the
fieldwork for this study on both instructional and
logistical grounds: packages were discarded if they were
perceived either as mismatched in some way to students’
needs and abilities or as too difficult, too
cost-ineffective, or too involved to implement
satisfactorily. Interestingly, these rejections did not
stem from any formal procedure for evaluating courseware:
the headmaster reported consulting reviews in a number of
computer magazines (although he admitted "I don’t find them
very useful") and using "a checklist in our heads" rather
than employing any of the commercially available courseware evaluation guides or services.

Content, then, to rely on their own judgment, experience, and knowledge of their students—even to the exclusion of outside sources—Marburn faculty seemed confident of their own abilities to determine if a package would be effective in their classes or if, as Teacher D noted, "it simply isn't worth it." Describing a personal bottom line for courseware rejection, this teacher revealed what is perhaps the school's ultimate criterion for courseware rejection as well:

[I wouldn't buy a particular package if] I wouldn't buy it if it were in a hardback or . . . a textbook. . . . Just because it pops on the screen and somebody is out there trying to make a buck on it, [I wouldn't buy it if] it simply isn't worth the money or the students' time.

**Logistics of Computer Use**

Teachers implemented the courseware that passed their scrutiny according to a variety of patterns, both procedural and instructional. Table 5, "Logistics of Computer Use," summarizes the procedural aspects of computer use at Marburn—the scheduling patterns teachers instituted in their classrooms, the devices they used to manage these patterns, the configurations of students they assigned to the computer, and the temporal patterns they
### Table 5
**Logistics of Computer Use**

<table>
<thead>
<tr>
<th>TEACHERS</th>
<th>Scheduling Devices</th>
<th>Groupings</th>
<th>Times</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consistent users/experienced</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher A</td>
<td>lesson plan</td>
<td>individuals (83)</td>
<td>1-40 minutes</td>
</tr>
<tr>
<td></td>
<td>schedule on board</td>
<td></td>
<td>mode = 10 mins.</td>
</tr>
<tr>
<td></td>
<td>student progress charts</td>
<td></td>
<td>more than 50% btwn.</td>
</tr>
<tr>
<td></td>
<td>student folders</td>
<td></td>
<td>8 and 15 mins.</td>
</tr>
<tr>
<td></td>
<td>automatic routing</td>
<td>groups (5)</td>
<td>10-40 minutes</td>
</tr>
<tr>
<td></td>
<td>staggered intro. of students, classes</td>
<td>pair (1)</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Teacher B</td>
<td>student folders</td>
<td>individuals (144)</td>
<td>1-35 minutes</td>
</tr>
<tr>
<td></td>
<td>student activity packets</td>
<td></td>
<td>mode = 5 mins.</td>
</tr>
<tr>
<td></td>
<td>sign-in sheet</td>
<td></td>
<td>approx. 80% btwn.</td>
</tr>
<tr>
<td></td>
<td>sign up on board</td>
<td>groups (8)</td>
<td>10-45 minutes</td>
</tr>
<tr>
<td></td>
<td>timer</td>
<td>pairs (8)</td>
<td>7-19 minutes</td>
</tr>
<tr>
<td>Teacher C</td>
<td>student progress charts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher D</td>
<td>pairs (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher E</td>
<td>student folders</td>
<td>individuals (28)</td>
<td>4-33 minutes</td>
</tr>
<tr>
<td></td>
<td>posted schedules</td>
<td></td>
<td>approx. 70% btwn.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>groups (3)</td>
<td>10 and 16 mins.</td>
</tr>
<tr>
<td>Teacher F</td>
<td></td>
<td></td>
<td>10-60 minutes</td>
</tr>
<tr>
<td>Teacher G</td>
<td></td>
<td></td>
<td>15-35 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15-40 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10-40 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30-40 minutes</td>
</tr>
</tbody>
</table>

**Sporadic users/experienced**

**Teacher C**

**Teacher D**

2/3 period after class activity

**Teacher E**

whole period

whole period (centers)

1/2 to 2/3 period after class activity

**Teacher F**

whole period

**Teacher G**

whole period (centers)

1/2 period after class activity

8-23 minutes
maintained for each of these configurations. Much of this table, which is intended primarily to provide background information against which teachers' instructional uses of computers can be discussed, is self-explanatory; however, highlighting its major themes should provide an appropriate context for discussing teachers' assignment patterns, which have both logistical and instructional aspects.

Instructional periods at Marburn last 45 minutes, and teachers who scheduled students for "whole periods" actually began to assign students after accomplishing several minutes of "housekeeping" chores at the beginning of this instructional time--returning homework, making announcements, etc. In some instances, these whole-period assignments involved using the computer as one of several learning centers in the room; in these cases, all the students in a class would disperse to their centers at the same time and the teacher would move through the classroom, monitoring each student's work, as the period progressed. More frequently, however, the whole-period assignments involved sending students to the computer one by one while the rest of the class engaged in another activity; in these cases, individual students would take turns using the computer, leaving and returning to their desks according to whatever scheduling device(s) the teacher had in use at the time.
A third scheduling pattern observed during the fieldwork involved sending the students to the computer, either individually or in pairs or groups, after the entire class had completed an activity—taking or reviewing a test, completing a regular silent reading session, engaging in whole-class instruction, etc. Students not assigned to the computer under this pattern would continue working at their desks while their classmates worked at the computer. Although the time most of the teachers devoted to computer use within this pattern remained fairly constant over the duration of the fieldwork, Teacher B gradually increased computer time from 5 or 10 minutes toward the beginning of Phase 2 to 30 or 35 minutes or even whole periods toward the end.

Managing individualized instruction for even a small class is a complex task, and the teachers—especially the "consistent/experienced" ones—used a variety of devices and approaches to oversee their assignments of individual students to the computer. Some of these—for example, individual and class progress charts—were supplied with the courseware with which they were used and posted near the computer so the students could "kind of see where they are" and the teacher could "see, without having to stick the [disk] in, where everybody is." Others—for example, sign-in sheets supplied with courseware and schedules
developed by the teachers—were also on public view but were used more to help both teachers and students keep track of students' turns on the computer than to chart their progress. Still others—for example, individual assignment and progress records—were either supplied with the courseware or developed by the teachers and placed in individual student folders or activity packets designed by the teachers to encourage students to gain responsibility for monitoring their own learning.

Both Teachers A and B used the chalkboard as a scheduling device. Teacher A worked directly from a lesson plan to specify both sequences and times for the students, which were then written on the board:

- 12:45 - 1 Student A
- 1 - 1:10 Student B
- 1:10 - 1:20 Student C

On one occasion, when an explanation of a worksheet had taken longer than anticipated and had run into the previously specified computer time, a swipe with an eraser enabled the teacher to revise the schedule so that each student would be able to work the allotted time.

Teacher B used the board in several different manners. One strategy involved having the student on whose activity packet the teacher had written a "1" sign up on the board first; then other students who
wanted to use the computer signed up under this first name on a first-come, first-served basis. In a variation on this approach, all the students to be assigned to the computer on a given day were given numbers on their packets, and they signed up in the order specified by these numbers.

Teacher B also experimented with setting a kitchen timer to govern students' use of the computer. Frustrated by students who would overstay the time appropriate to complete an assignment--thus making poor use of their own and their classmates' computer time--this teacher described the problem this way:

[with] some of the programs . . . [the students] would go on and on and it was hard for me to monitor when I'm running around the classroom. . . . So I think they need to know exactly what day and how long and that you definitely will catch them if they do not follow those rules. They need to know that just because they're in the back of the room with the computer the teacher still knows what's going on.

A timer that could be preset for a standard span within a program might be a better solution than one that must be set manually for each student, however: the kitchen timer was observed in use for only one day.

In contrast to Teacher B (who eschewed a program's automatic routing function in order to help students learn to proceed systematically) Teacher A relied on this function consistently. Also in contrast to other
teachers—who generally assigned all the students in a particular class to begin using the same program at the same time—Teacher A staggered starting students on the various courseware packages selected for use. Thus, some fifth-period students started to work on subtraction one day, several others and some sixth-period students started to work on decimals the next, and second- and fourth-period students were not assigned to the computer until about a week later.

Whatever the particular scheduling device(s) employed, teachers usually assigned students to the computer individually rather than in pairs or groups: 275 instances of individual assignment were observed during the fieldwork, while only 25 instances of group assignment and 16 of pair assignment were noted. In addition, only a few of the group assignments involved actual student work on a package; most concerned convening the entire class for the efficient introduction of new materials. These introductions—as well as other group and pair assignments—tended to last longer than individual sessions, which generally ranged between 5 and 15 minutes. The fourth column in Table 5 displays the ranges of times that each teacher's students spent at the computer and also includes other information (e.g., modes) intended to provide a sense of the overall temporal patterns of
teachers' decisions about their students' computer use.

**Teachers' Assignment Patterns**

Although the rather formal scheduling arrangements described above were the obvious norm during the fieldwork, teachers also subscribed to less obvious patterns while making their assignments. These patterns are more properly described as "instructional" than "logistical," and their existence suggests that implicit decisions about student learning accompanied and even superseded the assignment patterns made explicit through documents and clocks.

One of these implicit patterns involved responding flexibly to individual students' needs as these were perceived during instruction. For example, all the teachers observed to use the computer to any extent—that is, all except the "sporadic/experienced" teachers—tried to fold into existing schedules students who wanted to use the computer on a given day. While only one teacher was observed to make assignments by actually soliciting volunteers, all responded to students' requests to use the computer, to go first or next, and so on: "Can I work on the computer? Please? Can I see the computer? Please?" begged a boy who moments later was loading an integers program. Conversely, the formal schedules were not so readily altered to accommodate the few students who
resisted working at the terminals: "I know this isn't your most favorite thing," reasoned Teacher A, "but would you work on the computer for a while this morning? Just 15 minutes. Everyone else has done it twice, and you haven't done it at all."

This teacher's gentle goading of a reluctant student reveals another assignment pattern that augmented formal scheduling: teachers made a number of comments indicating a desire to be sure every student had an opportunity to use the computer. "Let's give someone else a chance--I want everyone to keep up," announced Teacher A in a different situation. "I know you're excited," commiserated Teacher B with one of the many students who, over a period of weeks, requested permission to do more than the segment originally assigned. But the limit stood so that everyone could have a turn.

This pattern of giving all students a chance to work on the computer was suspended in accordance with teachers' perceptions of what was best for their students. Teacher F, for example, expressed reservations about computer work for a particular student because it would "help him get away from other people, which he loves to do. He very rarely asks for help, and on the computer he would never ask for help." Teacher A chose not to use the computer in one class in which "things are pretty basic right now."
Right now one assignment in the book has been adequate for them to master something. So I really don't want to hold them back at this point with using the computer."

Undoubtedly the most intriguing assignment pattern--implicit or explicit, logistical or instructional--that emerged during the fieldwork involved the use of the computer for contingency management. Time and time again throughout the study, students were assigned to use their favorite resource as a reward for completing their other work. "How do we get to use the computer?" asked a student one Monday morning. "I'll probably pick people who are working real hard at their desks," responded Teacher B. Introducing another program to a different group of students the following Wednesday afternoon, Teacher A echoed the first teacher's words in explaining how assignments would be made: "I'll probably ask whoever's working hardest at his desk."

Over the course of the fieldwork, students were frequently assigned preferentially on the basis of diligence or good behavior. Teacher B, for example, explained that "We have a big problem in this class. ... you're not doing your work on your worksheets. So today only one person will work on the computer while the rest of you get caught up." Teacher F responded
affirmatively to a student's request to use the computer "if you've got a decent start on your report." And "____, you're sitting quietly," announced Teacher B to a group before giving the singled-out student first choice of roles in a simulation.

Perhaps the most striking illustration of the power of the computer as a contingency manager involved an exchange between Teacher B and a student who had particular problems with absenteeism and lack of motivation. Early in a Thursday morning class, the teacher had told the boy that he couldn't use the computer because he hadn't completed any worksheets that week. Later in the same period, when he asked again, Teacher B was able to respond enthusiastically: "Yes, you can. After _____. You've done two worksheets today!" When the period ended before he got his reward, the teacher assured him he could go first the next morning.

Clearly, the judicious use of this high-tech version of an approach that has long proven successful in various special education settings signals an effective assignment pattern for Marburn teachers. Replacing the familiar chits or points to be redeemed for candy or toys with a reward that has intrinsic value—and an additional opportunity to learn—seems a wise, if unanticipated, use of the computer as a powerful instructional tool.
Courseware selection and rejection, formal scheduling procedures, and informal assignment patterns all provide the backdrop for a discussion of the most significant aspect of teachers' use of computers at Marburn—the instructional strategies teachers developed to capitalize on perceived strengths and/or to compensate for perceived weaknesses in courseware in order to enhance the value of CBE for their students. Table 6, "Instructional Strategies for Computer Use," displays these strategies in three categories: techniques teachers used to introduce courseware and the computer to their students; the ways in which teachers intervened in students' computer work to assist them with stimuli, responses, and reinforcement; and the instances discovered during the fieldwork of teachers' integrating CBE with ongoing instruction.

Examination of the fieldnotes for this study revealed that by far the greatest amount of teacher involvement in students' computer use occurred when teachers were introducing new courseware packages. Only one teacher—a novice user who believed courseware should stand on its own—was observed to assign students to begin to use programs independently; all the others took the time themselves to introduce groups, pairs, and individual students to courseware they were encountering for the first
### Table 6: Instructional Strategies for Computer Use

<table>
<thead>
<tr>
<th>TEACHERS</th>
<th>Introductions</th>
<th>During Use</th>
<th>Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>users/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>experienced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher A</td>
<td>using student to demonstrate pointing out strategies</td>
<td>Stimulus pointing</td>
<td>designing class around program, including use of chalkboard and teacher-made worksheet</td>
</tr>
<tr>
<td></td>
<td>pointing to screen, keyboard</td>
<td>Response giving physical prompt</td>
<td>adding computer section to students' daily accomplishment sheets</td>
</tr>
<tr>
<td></td>
<td>motivating, telling what to expect</td>
<td>Reinforcement teaching from screen</td>
<td>using worksheet from other source</td>
</tr>
<tr>
<td></td>
<td>reading, explaining directions</td>
<td>pointing out strategy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>having students do samples</td>
<td>reading screen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>giving physical prompts</td>
<td>restating problems</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>reminding of objective</td>
<td></td>
</tr>
<tr>
<td>Teacher B</td>
<td>using student to demonstrate pointing to screen, keyboard</td>
<td>Stimulus pointing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pointing, explaining directions</td>
<td>Response explaining keyboard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>skipping directions to give own</td>
<td>Reinforcement teaching from screen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>having students read directions</td>
<td>pointing out strategy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>having student explain program</td>
<td>reading, explaining</td>
<td></td>
</tr>
<tr>
<td></td>
<td>motivating, telling what to expect</td>
<td>feedback</td>
<td></td>
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<tr>
<td></td>
<td>having students do samples</td>
<td>using chalkboard</td>
<td></td>
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<tr>
<td></td>
<td>giving physical prompts</td>
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<tr>
<td>Sporadic</td>
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<td>users/</td>
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<tr>
<td>experienced</td>
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<tr>
<td>Teacher C</td>
<td>matching what's available to students' needs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEACHERS</td>
<td>Introductions</td>
<td>During Use</td>
<td>Integration</td>
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<tr>
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</tr>
<tr>
<td>Teacher D</td>
<td>directing attention (narrowing) reading directions pointing to screen using chalkboard having students do samples</td>
<td><strong>Reinforcement</strong> confirming students' understanding suggesting auxiliary materials</td>
<td>using teacher-made study sheet making program part of larger unit</td>
</tr>
<tr>
<td><strong>Exploratory users/ novices</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher E</td>
<td>using student to demonstrate having students read directions having student explain program</td>
<td><strong>Reinforcement</strong> explaining reason for error</td>
<td></td>
</tr>
<tr>
<td>Teacher F</td>
<td></td>
<td><strong>Reinforcement</strong> encouraging student to figure it out</td>
<td></td>
</tr>
<tr>
<td>Teacher G</td>
<td>using student to demonstrate pointing to screen, keyboard reading, explaining directions having student read directions skipping directions to give own pointing out strategy motivating, telling what to expect using chalkboard giving physical prompt</td>
<td><strong>Response</strong> giving hint <strong>Reinforcement</strong> teaching from screen</td>
<td>building unit around program</td>
</tr>
</tbody>
</table>
time. Thus, in spite of many references in the literature to the power of the computer to promote independent learning and many comments during the study about the importance of encouraging such independence, Marburn teachers' behavior indicated that this goal has not been fully realized with CBE. Even though teachers responded that they did not see it as inherently part of their role to introduce students to courseware and agreed that it would be preferable if the students could use programs independently, they seemed resigned to the fact that their getting students started with new courseware would continue to be the norm: "These are LD children," pointed out Teacher B, "and they might read the directions backwards"; "I pretty much always assume that these guys are going to have trouble [understanding the directions]," agreed Teacher A.

Thus teachers who participated in the study generally took great care introducing new courseware packages and whatever particular computer functions a package might entail. Usually the introductions were whole-class activities:

I think that for the things that we use all the time it's just easier all around to just go through the directions, let them ask questions, and then everyone can understand what it is. ... that way they can be more independent when you send them over there. ... If you didn't, every time someone would go over, then you'd have
Several factors, however, necessitated that the group introductions be supplemented or replaced with other approaches: the absence of a student on the day of the group introduction, the need for extra attention for a younger child or for one who failed to understand or to remember the initial introduction, and the assignment of individuals or pairs of students to programs different from the ones used by their peers all required the teachers to spend additional time introducing courseware to their charges. This investment of time was particularly evident with Teacher B, who oversaw individual students' initial work on the computer almost every day—reminding them of their turns, making sure they got into the correct programs, and hovering nearby long enough to be sure they could complete their assignments successfully.

Teachers routinely used several strategies in their introductions. Calling on a student to walk through the program ("___, will you be my helper?") was an approach used with virtually every new courseware package, whether the introduction involved groups or individuals. Directing students' attention to the appropriate stimuli or keys was another widely used strategy: teachers pointed to salient aspects of the screen and the keyboard with a variety of
tools, including index fingers, little fingers, and a black felt-tipped pen. Teachers also directed students' attention verbally in both general and specific ways: "You need to pay attention. You especially need to be good listeners and to use your eyes," cautioned Teacher B during one introduction. "Pay attention to the question mark. Wherever the question mark is is where the number you type is going to appear," suggested Teacher A in another. "Do you think you can give me your full attention while I go over it?" asked Teacher G in yet another instance—requiring every student in the group to answer yes before the activity continued. One teacher, Teacher D, used auxiliary materials to direct students' attention to the computer task at hand: working with a map of the United States, this teacher progressively narrowed students' focus, first to the Eastern states and then to the New England ones whose capitals they would be identifying on the screen.

By far the most significant aspect of teachers' extensive involvement in introducing courseware to their students, however, involved their development of a repertoire of strategies to compensate for students' almost universal inability to read and understand programs' directions. To this end, teachers read directions aloud to their students, required students to read those directions
aloud, augmented directions with their own explanations, asked students to explain directions for programs in their own words, and even ignored directions altogether in favor of giving their own explanations of program objectives and tasks.

Evidence of the consistent use of each of these strategies abounds. Teachers almost always read directions aloud, at least for students’ very first encounter with a new package: Teacher B, for example, would read not only directions but menus of options while pointing to each word along the way. Teacher E provided a humorous example among the many instances of teachers’ having students themselves read directions aloud: asking rhetorically, "Now you would like instructions, wouldn’t you?" this teacher was not about to leave such a crucial decision to this impish student’s discretion. Teacher B offered a good illustration of teachers’ augmentations of instructions by having students read the directions for a learning game, further explaining the game through an analogy to a common children’s game, and reiterating some of the key features students needed to know to play the game successfully. And although teachers generally encouraged students to read or listen to instructions, in some cases even this tactic was abandoned: several teachers allowed students to skip directions if they could explain program requirements
satisfactorily and several skipped directions themselves to rely on their own explanations. Teacher G, for example, having watched one group of students struggle through the directions of a particular program, announced to the next class that students should skip the directions entirely while the teacher explained the program instead.

While these strategies—using students to demonstrate, directing students' attention in various ways, and ensuring that students understood directions—were the primary techniques teachers used to introduce courseware, they employed a variety of other approaches as well. Teachers actively tried to motivate students and to set their expectations for what was to come; they had students do sample problems or questions, standing by until sure the students could proceed on their own; they used the chalkboard to help explain a program or to display information that might be helpful to the students once they were on their own. Occasionally teachers even used physical prompts: showing several students where to place their fingers on the keyboard, pointing a girl's finger to the appropriate spot on the screen, preventing a boy from responding impulsively before an explanation was complete.

One interesting aspect of teachers' introductions involved suggesting particular strategies students might use to complete their work successfully. Although this was
not observed to happen often, the instances in which it did seemed very helpful to the students involved. One morning, for example, Teacher G had to provide a great deal of assistance to a boy who was about to use a spelling game—helping him read such words as "hidden," "guess," and "is" and spelling "lesson" for him so he could call up the word list that had been entered for the class to use. When the boy had difficulty with the first word the game asked him to spell, the teacher suggested that he use his spelling book to help him determine which words the game called for in each round. And when he announced a few minutes later that he had been successful with this strategy, the teacher encouraged him to go beyond it: "Do it with your book. Then do it without your book. That will be your challenge." The teacher thus provided him with a match-to-sample strategy that enabled him to approach the program initially and then tried to move him to the more difficult recall task that actually constitutes learning to spell.

Teacher A suggested a variety of strategies while introducing students to several kinds of math courseware. Students working game programs, for example, were advised to position their fingers in ways that would allow quick responses and to "go after the closest" problem in a speed drill. Students using "workbook" programs were routinely
reminded to "Use your scrap paper" and were occasionally encouraged to use other math tools in the classroom to help them with concepts the teacher knew they found troublesome.

Once students had been introduced to programs, most teachers allowed them to proceed on their own until they encountered difficulties. Although Teacher B often stayed with students beyond the introductory point—reminding them of objectives, restating problems in different terms, reading and pointing to the important elements of a stimulus—the other teachers generally left the students alone until and unless they needed help. At this point, however, teacher involvement became heavy once again, suggesting that the feedback and reinforcement provided by the courseware was often inadequate for these LD students and that teacher intervention was critical to students' successful completion of their learning tasks.

Teachers' most frequent strategy at this point involved enlisting the computer as a teaching tool—using the problem and feedback on the screen as the basis for instruction on the concept at hand. Teacher A, for example, would consistently read the display to a student who was having difficulty ("'Round the number to the nearest integer'"), probe to discover the source of the student's error ("Do you know what an integer is?"), and lead the student through the problem ("It's showing you,
step by step") to its correct answer. Other teachers took similar tacks—walking students through problems, explaining keyboard functions as necessary ("No, you use an arrow. That's a comma, not an arrow"), and focusing students' attention on what they had failed to see on the screen or to understand about the underlying concept.

In all these instructional sessions, teachers tried to do what the courseware feedback generally did not: explain the reason for the student's error. "Let's look at this," suggested Teacher G in a common teacher response to a student's mistake. As the class looked on, the teacher listened to the student's explanation of the reason for her response to the multiple-choice question, agreed that she had a good point, explained why another of the answers was the correct one, and generalized from this specific example to an explanation of the principle upon which the item was based.

Teachers also employed other strategies to enhance or compensate for reinforcement provided by courseware. Teacher C, for example, stood by to confirm students' belief that their answers were correct. Teacher F told a boy, "You're smart enough to figure that out for yourself"—at the same time hunkering down next to him to provide whatever help was needed. Teacher B read and explained feedback to students and used the chalkboard to
explain that a subtraction problem shown in an unfamiliar vertical format on the computer is no different from the same problem expressed in the horizontal format that the student had encountered before.

As they did in the introductions, some teachers also pointed out strategies students could use to overcome their difficulties. While these generally involved techniques related to specific situations—Teacher A, for example, explained several math strategies and suggested tools, like graph paper, appropriate to particular tasks—some were more global in nature. Teacher A provided transferable advice in an encouragement to "think about this" rather than hurrying during a program in which students were to solve a problem in the least number of tries. This teacher also contributed to a litany heard throughout the fieldwork: "If they give you some print, please read it. Don't miss out on that information."

The primary way in which CBE at Marburn was integrated into ongoing instruction involved the implementation of courseware in which the content closely paralleled classroom activities. Since by far the most extensive use of the computer was to provide d & p on math concepts and facts, this kind of integration was obviously easy to accomplish. Few instances of more systematic integration were observed during the study, however, and interest in
this approach was expressed only in response to interview questions. The interviews revealed, for example, that no overt attempts were being made to tie students' computer experiences to the goals specified for them on their individualized education plans. "I think that would be excellent," responded one teacher in a statement that echoed the views of several others; beyond a general attempt at "looking at the software that we have and seeing if we can use that to help the student attain his goals," however, this method of integration was not being pursued.

Several other integration strategies were observed during the fieldwork, but none was extensive or prominent. Teacher D, for example, briefly used a courseware package about a facet of the electoral process as part of a larger unit on elections and developed a study sheet to accompany this activity. Teacher B included a segment on computer use on sheets summarizing students' accomplishments each day and once used a set of worksheets supplied with a noncomputer instructional package to expand upon students' work with a computer one.

In fact, during the course of the fieldwork, only two examples of elaborate efforts at integration were uncovered—-one through observation and one through a teacher's self-report. In the first instance, Teacher B was observed to conduct a class built around a computer
simulation; the lesson included a worksheet created by the teacher and involved building a chart on the chalkboard to expand upon the interrelationships introduced in the simulation. In the second instance, Teacher G—a "novice" teacher—reported building a set of learning centers around a package found to be especially useful: after using a simulation at the "computer center" to learn about writing a newspaper article, students were assigned to other centers to write their own articles "using the who, what, where, and when—sort of to reinforce what they were doing on the program." This reversal of the anticipated approach of using courseware to supplement instruction suggests that teachers will indeed try to find creative ways to integrate courseware they perceive to be effective, attractive, and useful.

Indeed, responses to interview probes revealed that teachers in each group were willing and even eager to discover ways to integrate CBE into other instruction: "I'm always open—I don't know everything," noted a consistent user; "I would take more suggestions," agreed a sporadic user. And "If there were a course . . . where you were told not just how to work it but how to handle a classroom and how to work it into a classroom, that might be very valuable," lamented a novice. The dearth of attempts at courseware integration at Marburn, then, may
not be a permanent condition.

In summary, teachers' uses of instructional strategies to enhance students' CBE experiences peaked during the introduction of new courseware and during the provision of reinforcement when students encountered difficulty with that courseware. Teachers employed a variety of strategies at these points, most involving attempts to help both middle and upper division students to compensate for their lack of reading skills and to understand the errors they had made. The fact that students were unable to do either of these things without extensive teacher intervention suggests that currently available courseware is inadequate to foster truly independent learning for many LD students. Teachers made few attempts to integrate courseware into their ongoing instruction in any systematic or elaborate way. While this suggests that teachers are generally content to let computer programs stand alone, the findings that some attempts at integration were made and that teachers expressed openness to ideas for integrating courseware more effectively suggest that teachers are willing to pursue this approach when it seems appropriate.

Conclusions and Implications

The summaries provided for each of the findings subsections of this chapter include the most important
conclusions to be drawn from those findings. The purposes of this section, then, are to relate those conclusions to the research questions and to discuss their implications for instructional design.

Teachers' restraint about the effectiveness of CBE suggests that these participants are neither awed by the technology nor committed to it without reservation. Clearly, courseware designers should continue to capitalize on the power of the computer to enthrall students but should work more diligently to create materials that make courseware quality rather than computer location the primary reason for student involvement. Courseware should be tested so that teachers have more confidence in its value; documentation should stress the results of such testing, should include suggestions to alleviate teachers' concerns about a variety of implementation issues, and should provide ideas for ways to use CBE specifically to foster noncognitive skills rather than assuming their automatic acquisition.

Although theorists in the field of CBE contend that d & p courseware neither makes the best use of computer technology nor promotes learning at advanced levels, the fact that this kind of courseware is both widely used and widely preferred at Marburn suggests that it has a prominent place in the resource collections of schools and
programs for the learning disabled. Thus, while efforts to develop more sophisticated kinds of packages for mildly handicapped students should certainly continue, efforts to create effective materials in the d & p format should also proceed. LD students often have superb reasoning skills but considerable difficulty mastering the basic facts and concepts on which higher levels of learning depend; interesting, attractive, and effective d & p courseware could contribute substantially to these students' learning of information upon which they can build.

While a variety of materials exist to help students master math facts, far less seems to be available to support other content domains. The lack of good language arts packages seems especially problematic and certainly contributes to the scarcity of CBE in this area. Basic aspects of punctuation, capitalization, and sentence construction might be particularly useful language arts topics for courseware to address; designers should be attuned to the need for such packages in the field.

Whatever format a particular courseware package for these students takes, that package should be—above all else—flexible. And instructional designers should attend to both the instructional and the logistical dimensions of flexibility. Because the LD population is notorious for variability both within the group and in each student's
day-to-day performance, courseware for these students should include functions that give the teacher simple and straightforward control over a range of instructional dimensions: content, level of difficulty, pace, and—when the technology allows for it—multisensory input and output. Content that remains challenging even after several uses and mechanisms that route students automatically through that content and provide diagnostic feedback about their performance with it are also essential for allowing teachers to orchestrate truly individualized instruction for their classes.

Logistically, courseware should be flexible enough to be used in a variety of situations—supporting the curriculum rather than supplanting it, adaptable (if possible) to various curriculum areas, and capable of fitting into a variety of teacher assignment patterns and time frames. Record-keeping routines and "save" options are also necessary to allow teachers to implement courseware efficiently and effectively. And, since monitoring students' computer work can be difficult and time-consuming, documentation that includes schedules and progress records is also a requirement.

Instructional designers should be sensitive to the fact that courseware is frequently implemented for purposes beyond those assumed by its creators. Because of this,
documentation that suggests ways to enhance social as well as cognitive learning might be very useful: teachers of the mildly handicapped are often concerned about their students' intense needs to learn to work together and to proceed systematically. And given the power of CBE as a contingency manager, designers should take special care that programs that are attractive for students to use are instructionally worthy of that use.

The fact documented in this study that using courseware with LD students can require considerable teacher involvement--instructionally as well as logistically--should be of special concern to courseware designers. Although some level of involvement while students are at the computer is inevitable and even desirable, the excessive amount that seems to be the norm at Marburn is a problem that could be alleviated to some degree by better design. Factors that would allow students to proceed more independently--simpler, perhaps graphically based directions; suggestions of strategies for getting answers; feedback that explains students' mistakes--could all allow teachers to take better advantage of the computer's power to foster independent learning. Although teachers never complained about the instructional time required to introduce and implement courseware, packages that reduce that time would certainly be useful. The time,
in fact, might be better spent implementing suggestions for integration—which should also be included in CBE packages.

Marburn teachers' perceptions and behaviors in relation to the use of CBE courseware are, of course, limited by their own situations and experiences. While these limitations may hinder the applicability of these findings to other teachers and situations, nevertheless the insights provided by the words and actions of these participating teachers suggest a number of implications for instructional design.
"How many of you have computers at home?" asked Teacher B to begin an introduction to the computer for the middle division. Ten hands shot up immediately and one small voice piped smugly that his family had three. In response to the next question—"How many of you have ever used a computer?"--fourteen hands waved in the air. Only one student present that day--a girl who seemed rather awed at the worldly wisdom of her classmates--was new to the computer: "I never used it before in my life."

Many Marburn students are, in fact, experienced computer users. Over 50 students responded to an interview question about having access to computers at home or in other out-of-school settings and over 30 answered affirmatively. Students' reported uses of computer hardware were also widespread: various students explained that they play games (the most frequently reported use), type letters and reports, draw, program (including graphics), and "chart the NFL football games." A half-dozen upper division students peppered their remarks with references to BASIC, low-resolution graphics, bulletin
boards, disk copying, a number of computer functions and peripherals, and the comparative strengths and weaknesses of popular computer accessories and systems. Although the middle division students did not generally exhibit the level of computer sophistication revealed by the older ones, they, too, were frequently able to compare Marburn’s courseware and computers with others they had used. And students in both divisions had discovered opportunities for mischief in the technology: Teacher A reported that an upper division student had once broken into a records program and replaced all the students’ passwords with dirty words; a middle division student being used to demonstrate a program during the introduction described above asked, "Can I get it wrong?"—apparently well aware that the rewards for errors in many programs are more entertaining than the rewards for success.

Students’ general familiarity with computers and computer based education (CBE) provides the background for this chapter’s presentation of the findings of the study about students’ perceptions and behaviors related to courseware. While this familiarity may make Marburn students substantially different from their learning disabled (LD) peers in most resource rooms and other public school programs across the country, it suggests the level of awareness many LD students are likely to have in the
future. As the amount of CBE offered to handicapped students continues to increase (Blaschke, 1985) insights gleaned from studying a small number of students in the vanguard may become increasingly applicable to the LD population at large.

Computer Use by Marburn Students

Tables 7 through 12 present various facets of Marburn students' uses of computers and courseware: their perceptions of the effectiveness of CBE and their interactions with it in the three areas addressed by the research questions (stimuli, responses, and feedback and reinforcement). As with the tables devoted to presenting teacher data, these displays were developed according to certain specific procedures and criteria that are important to consider when interpreting the information the tables contain.

First, student data is reported by group rather than individually. Not only the large number of student participants but also the goals of the research suggested that group reporting was most appropriate for this aspect of the study. Aggregating insights gleaned from all student participants and through all three data collection methods allowed the creation of a composite portrait of students' perceptions and behaviors based upon the widest
range of information available. Thus, contributing to the picture that emerged for each group were the variety of students who might be found in any classroom: students who had varying degrees of computer and verbal skills, who used courseware both frequently and infrequently, and who were enrolled at the school during part or all of the fieldwork period. Students were subdivided into categories that reflect their placement in the school and the timing of the fieldwork--middle division, upper division (Phase 1), and upper division (Phase 2)--both to facilitate the organization of the data analysis and reporting and to enhance the usefulness of the findings for Marburn and for others concerned with the perceptions and behaviors of students within particular age ranges.

Second, all summarized data entries (i.e., those without plus signs or quotation marks) represent the views or behaviors of at least two students, usually more. These entries are listed in descending order in each column in each table according to frequency of occurrence; any instance related to only one student in a group is followed by an asterisk (*) and is included because a student or students in another group or groups expressed a similar view or exhibited similar behavior.

Third, unconfirmed, idiosyncratic views and behaviors were incorporated into the tables when such instances were
directly related to one of the research questions or when they provided examples of actions or perceptions that were strikingly different from the norm or particularly insightful reflections of it. This kind of information is clearly marked with a plus sign (+) each time it appears and is thoroughly explained in the accompanying text. Information enclosed in quotation marks can also be considered idiosyncratic, since in each case it obviously emanates from a single source, and was included either to present information in the most direct and economical form or to provide especially astute or revealing examples of students' views. The accompanying text clarifies the degree to which all the idiosyncratic entries represent typical or disconfirming perspectives.

The application of these three decision rules—the inclusion of information from and about the full range of students, the confirmation of all summary data by at least one second source, and the clear identification of idiosyncratic data—makes each table representative of the student participants as a whole without sacrificing the particular responses of individual, perhaps dissenting, students. The representativeness enhances the credibility and transferability of the findings, while the inclusion of responses outside the norm reduces the possibility of investigator bias (Guba, 1981). In addition, the inclusion
of anomalous responses often yields valuable, insightful suggestions for the improvement of courseware.

**Perceived Effectiveness of CBE**

The students who participated in the study were more sanguine than their teachers about the academic benefits of CBE: virtually all the students expressed a strong belief that using the computer helps them learn, and even their scattered negative comments were colored by specific difficulties or complaints. Table 7, "Students' Perceptions of Academic Effectiveness," reveals both the particular things students perceived the computer to help them learn and the reasons students suggested for this learning.

Students' responses about what they learn reflect the relative levels of computer sophistication described above: middle division students responded most frequently that computer use helped them to acquire computer related skills--programming, "how to turn it on," and "where the keys are and stuff"--while only one upper division student mentioned that area. Not surprisingly, students in all three groups cited math as the primary subject matter they learned with the help of the computer, while various language arts skills (spelling, reading, vocabulary) were also mentioned, although less frequently. Several students
<table>
<thead>
<tr>
<th>STUDENTS</th>
<th>Perceptions</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle division</td>
<td>Positive</td>
<td>how to use computer math spelling speed reading* eye-hand coordination*</td>
</tr>
<tr>
<td>Neutral</td>
<td>“Sometimes it’s for fun.”</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>“It’s harder to do this at the computer.”</td>
<td></td>
</tr>
<tr>
<td>Upper division (Phase 1)</td>
<td>Positive</td>
<td>math vocabulary how to use computer*</td>
</tr>
<tr>
<td>Neutral</td>
<td>“It could be helpful maybe in reading.”</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>“Yes and no. It does and it doesn’t help in some ways.”</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>“The computer helps you if you want to do work on it and stuff.”</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>“I don’t think it helps me.”</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>“You’re not kept on task.”</td>
<td></td>
</tr>
<tr>
<td>Upper division (Phase 2)</td>
<td>Positive</td>
<td>math, including speed reading eye-hand coordination*</td>
</tr>
<tr>
<td>Neutral</td>
<td>“It can if you want it to.”</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>“Computers don’t help you learn anything.”</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>immediate feedback*</td>
<td></td>
</tr>
</tbody>
</table>

*Singular instances within groups repeated in other groups.
+Singular, unrepeated instances of particular significance.
commented that computer use had increased their eye-hand coordination, and several spoke of its help in increasing their response speed: "I can look at 'em faster," explained one middle division boy.

Perhaps most notable among the reasons volunteered for the computer's efficacy was the view expressed by students in both age groups that typing makes it easier to learn with the computer: "It's easier to type it than to write it," explained one middle division girl; "It helps 'cause you can type in the answer rather than write it down on paper," echoed an upper division boy. The fact that ease of response was students' most frequently mentioned reason for the computer's effectiveness supports a view held by many who tout this aspect of CBE for LD students. Given many such students' frustrating struggles with reversing letters and numbers, avoiding smudges and erasures, and writing or printing in straight lines, it is not surprising that the removal of such difficulties does in fact make it easier to concentrate on the content to be learned.

Students also cited a number of other advantages often mentioned in the CBE literature: immediate feedback ("It always tells you right when you make a mistake, not afterwards"); error correction ("You can correct it if you make a mistake"); and the provision of practice ("It gives you times and plusses and take aways"). Older students'
suggestions of some additional reasons—compensation for short-term memory deficits ("If you forget, it’s right up there") and the motivation provided by challenge ("You have to figure how to do it yourself")—once again indicate the comparative sophistication of this group.

Students' neutral comments generally reflect a view the children shared with their teachers that the computer is a tool whose value depends on the uses to which it is put. Upper division students in particular seemed to understand the relativity of the computer's role and the primacy of their own in determining whether a session with the hardware is educational. Somewhat different but of particular importance in the "neutral" category is the suggestion that "Well, I'm sure it helps but it doesn't explain, doesn't give instructions." Offered as a concluding statement to a series of positive and negative comments in a group interview, this insight supports the finding reported in Chapter IV concerning teachers' need to enhance or compensate for inadequate feedback by explaining the reasons for students' errors.

Only a few students expressed negative views about CBE. Several were disturbed when particular aspects of courseware confused them: students would occasionally misread mathematical signs, for example, perform the wrong operations, and get answers wrong. Some students also saw
no value in drill and practice programs in which they "just sit there and punch return" or "add it up . . . print it, and use it as a game." Interestingly, the one student who was most vocal in his objections reconsidered his stance during an interview in which others pointed out some advantages of the game format he had disparaged: "I guess you're right when you think of it that way."

The most interesting of the negative comments, however, came from several students who complained about the time lag between the presentation of problems in a particular program. The program is designed so that a completed problem remains on the display for several seconds until the next (including, apparently, the graphic reinforcement for its correct answer) is fully loaded and ready to appear. "I find myself drifting," explained one upper division girl:

because [after] you get it right, they'll leave it up there for, like, 10 seconds. And then it takes . . . like 10 more seconds to erase it and get another problem on there. . . . In those seconds I'm just sitting here going like this, looking out the window. By the time the new problem gets up, I'm not really [doesn't finish].

These comments were echoed by several other students and illustrated by the behavior of many more during the observation sessions: both younger and older students complained about several programs they found slow to load ("Takes 'em long enough," growled one middle division boy);
often fidgeted; and rarely, if ever, looked at the problems that remained on the screen for them to study in this particular program. One afternoon an upper division boy provided a striking illustration of the effects on concentration of the latency between problems: after hitting the return key repeatedly as if to make the problems appear more quickly, he softly counted aloud to six. His explanation revealed what he was actually attending to in the interval during which he was supposed to be studying the problem: he was counting "how long it takes a problem to disappear" before the next one came on the screen.

In summary, Table 7 reveals few surprises but instead reflects a number of findings and suggestions from other sources: that students' attitudes toward CBE are generally positive; that most courseware (and therefore most computer learning) involves math; that older students are more sophisticated than younger ones in several ways; and that typing is an especially important aspect of CBE for LD students. Two of the findings reported in this table, however, do suggest aspects of CBE that emerged as important in this study but have not been reported elsewhere: students' concerns about courseware that does not explain the reasons for errors reinforce a similar viewpoint held by Marburn teachers, while students'
complaints about the time lag between problems provide an insight that became available only through their own unique perspective. Instructional designers could address the former problem by anticipating common errors and including possible explanations for them in the feedback/remediation segments of courseware. Designers could address the latter problem by using quick-draw graphics (in spite of their extensive memory requirements) or by foregoing some of the more elaborate displays that take so long to load.

**Students and Stimuli**

Table 8, "Students and Stimulus Characteristics," displays the ways students interacted with characteristics of the stimuli presented in various kinds of courseware. Like the tables presenting students' interactions with response and reinforcement characteristics, this table shows the difficulties students encountered with each kind and the strategies—both successful and unsuccessful—they used in these encounters. Also like the other tables displaying facets of student interaction, Table 8 presents problems and strategies not in a one-to-one relationship but in order of frequency of occurrence within each category.

It is important to note that, for the most part, students interacted successfully with the courseware in use
<table>
<thead>
<tr>
<th>STUDENTS CHARACTERISTIC</th>
<th>PROBLEM</th>
<th>STRATEGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle division</td>
<td>Verbal procedures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>difficulty getting to option or level</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td>forgetting password</td>
<td>experiment, then ask</td>
</tr>
<tr>
<td></td>
<td>typing error(s)</td>
<td>read aloud</td>
</tr>
<tr>
<td></td>
<td>wrong disk</td>
<td>experiment/figure out*</td>
</tr>
<tr>
<td></td>
<td>reading bottom line only</td>
<td>ask another student*</td>
</tr>
<tr>
<td></td>
<td>directions</td>
<td></td>
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<td></td>
<td>failure to understand</td>
<td>read on first encounter</td>
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<td>avoid/figure out</td>
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<td>avoid after first encounter</td>
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<td>read after first encounter</td>
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<td>ask teacher or researcher</td>
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<td>read aloud</td>
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<td>point</td>
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<td>talk self through</td>
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<td></td>
<td>return if puzzled</td>
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<tr>
<td></td>
<td>content</td>
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<td></td>
<td>nonsense words</td>
<td>read aloud</td>
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<td></td>
<td>too complex</td>
<td>point</td>
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<tr>
<td></td>
<td>general reading difficulties</td>
<td>ignore part</td>
</tr>
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<td></td>
<td></td>
<td>call for silence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>page through*</td>
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<td></td>
<td>Numeric</td>
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<tr>
<td></td>
<td>horizontal format</td>
<td>point</td>
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<tr>
<td></td>
<td></td>
<td>say aloud</td>
</tr>
<tr>
<td></td>
<td>Graphics/ sound</td>
<td></td>
</tr>
<tr>
<td></td>
<td>presence/absence of sound</td>
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<tr>
<td></td>
<td>tunneling</td>
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<tr>
<td></td>
<td>distracting graphics</td>
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<td></td>
<td>design confusion</td>
<td></td>
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<td></td>
<td>color confusion</td>
<td></td>
</tr>
<tr>
<td>Motivation</td>
<td>game formats</td>
<td>augment competition</td>
</tr>
<tr>
<td></td>
<td>other formats</td>
<td>introduce competition</td>
</tr>
</tbody>
</table>

*Singular instances within groups repeated in other groups.*
Table 8 (cont'd.)

<table>
<thead>
<tr>
<th>STUDENTS CHARACTERISTIC</th>
<th>PROBLEM</th>
<th>STRATEGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper division</td>
<td></td>
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<tr>
<td>(Phase 1)</td>
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<td></td>
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<tr>
<td>Verbal procedures</td>
<td>forgetting password</td>
<td>experiment, then ask</td>
</tr>
<tr>
<td></td>
<td>failure to understand</td>
<td>read aloud</td>
</tr>
<tr>
<td></td>
<td>typing error*</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td>reading bottom line only*</td>
<td>ask another student</td>
</tr>
<tr>
<td></td>
<td>directions failure to understand</td>
<td>avoid/figure out</td>
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<td></td>
<td></td>
<td>read on first encounter</td>
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<tr>
<td></td>
<td></td>
<td>ask teacher or researcher</td>
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<tr>
<td></td>
<td></td>
<td>read aloud</td>
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<tr>
<td></td>
<td></td>
<td>return if puzzled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>read after first encounter*</td>
</tr>
<tr>
<td></td>
<td>content general reading difficulty</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td>nonsense or foreign words</td>
<td>read selectively</td>
</tr>
<tr>
<td></td>
<td></td>
<td>terminate</td>
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<tr>
<td></td>
<td></td>
<td>point</td>
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<tr>
<td>Numeric</td>
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<tr>
<td>Graphics/sound</td>
<td>presence/absence of sound</td>
<td>n.a.</td>
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<tr>
<td></td>
<td>distracting graphics/sound</td>
<td>introduce competition</td>
</tr>
<tr>
<td></td>
<td>insufficient highlighting+</td>
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<tr>
<td>Motivation</td>
<td></td>
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<tr>
<td>game formats</td>
<td></td>
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<tr>
<td>other formats</td>
<td></td>
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</tbody>
</table>

*Singular instances within groups repeated in other groups.
+Singular, unrepeated instance of particular significance.
Table 8 (cont'd.)

<table>
<thead>
<tr>
<th>STUDENTS CHARACTERISTIC</th>
<th>PROBLEM</th>
<th>STRATEGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper division</td>
<td>Verbal   procedures</td>
<td></td>
</tr>
<tr>
<td>(Phase 2)</td>
<td>difficulty getting to option</td>
<td>experiment/figure out</td>
</tr>
<tr>
<td></td>
<td>or level</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td>failure to understand</td>
<td>experiment, then ask</td>
</tr>
<tr>
<td></td>
<td>wrong disk</td>
<td></td>
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<td></td>
<td>typing error(s)</td>
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<td></td>
<td>forgetting password*</td>
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<td>directions</td>
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<td></td>
<td>failure to understand</td>
<td>read on first encounter</td>
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<td></td>
<td>foreign word</td>
<td>avoid after first encounter</td>
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<td></td>
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<td>ask teacher or researcher</td>
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<td>content</td>
<td>read after first encounter</td>
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<td>general reading difficulties</td>
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<td></td>
<td>Graphics/ sound</td>
<td>distracting graphics</td>
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<td>Motivation</td>
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<td>game formats</td>
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<td>other formats</td>
<td>introduce competition</td>
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<tr>
<td></td>
<td>♦Singular instances within groups repeated in other groups.</td>
<td></td>
</tr>
</tbody>
</table>

*Singlar instances within groups repeated in other groups.
at Marburn during the fieldwork. Because the purpose of this report is to identify problems in interaction in an attempt to suggest areas of courseware that could be improved, the focus of the document is necessarily on problems rather than successes. However, this focus should not obscure the fact that, in general, students—with and without the help of their teachers—had positive encounters with courseware. Problems that arose were usually resolved quickly and with little or no disruption of classroom flow. While some pervasive problems did indeed surface during the fieldwork, these rarely prevented students from using courseware with at least some degree of success.

It is also important to note that table entries for each of the three major segments of each table—middle division, upper division (Phase 1), and upper division (Phase 2)—do not necessarily apply with equal force to the others. Rather, each segment reflects the different types of courseware used in each division and, in the case of the upper division, during two academic years. Thus, problems and strategies related to a spelling program used only by the middle division are not reflected in the segments of the tables dealing with the upper division. Similarly, strategies developed by Phase 2 students to deal with math game programs are not reflected in the Phase 1 segment of the table because these programs were not in use during
that earlier period. A number of other discrepancies in
the courseware used across the three segments also affected
the composition of the table.

Entries in each table segment also reflect the
implementation strategies chosen by the various teachers
who participated in the study. For example, upper division
students whose teacher opted to use a program's automatic
routing function could be expected to have fewer
difficulties getting to the appropriate level than middle
division students whose teacher shunned the function in an
attempt to help students become more aware of the
importance of sequence and procedure. Similarly, students
encouraged to explore complex programs independently could
be expected to encounter greater problems than students
assigned to use drill and practice lessons under close
teacher supervision. Thus, differences in both content and
approach across the three segments of the study population
suggest that, while general conclusions about students' interactions with various instructional characteristics of
courseware can certainly be drawn, many of the findings
summarized in the tables and discussed below must be interpreted in light of a number of constraints.

Verbal. Students in all three groups of study
participants encountered some difficulties with the verbal
instructions they needed to follow in order to gain access
to courseware. Middle division students, for example, would forget the option they had been instructed to choose and be unable to read the display well enough to make the correct choice on their own; some upper division students, too, had problems reading and understanding displays about such procedural matters as getting to the appropriate segment of a program, exiting it, and getting the teacher. One upper division boy went through the same "exit" display twice—each time reading it very carefully but failing to understand the display's instructions to get his teacher and assuming that he had made an error that prevented the program from moving on.

Students in both groups forgot their passwords or encountered difficulties in entering them: several upper division students mistyped their passwords (their names) and failed to understand why a program would not route them to their predetermined assignments. Middle division students, all of whom used the same password, also had typing difficulties: in one extreme but illustrative instance, a boy mistyped the password six times—even though it was posted on the computer directly in his line of vision between the keyboard and the screen—and failed to see his error until his teacher pointed it out.

Students would also occasionally select the wrong disk for their assignments or try to proceed when a disk other
than the one containing their assigned program had already been loaded. While this kind of error did not always involve problems with reading ("That's not what it's supposed to say") there were times that it did. Teacher A, for example, reprimanded a student for choosing the wrong disk and told him that in the future he should look for the first letters on the disk labels so he could find the correct disks "even if you can't read 'em."

One of the most interesting of student difficulties, however—and one that could be alleviated by different display design—involved several students' propensities for reading the bottom lines of displays without reading any of the preceding text. One middle division boy, for example, wanted to follow the last line's instructions to press return even though the disk drive was whirring and the word "loading" flashed in inverse video at the top of the screen; an upper division boy immediately and mistakenly chose the last line's "escape" option in spite of the fact that a half screen of text appeared above it. Other students, too, went directly to the last lines of displays, suggesting that perhaps these running lines—typically ignored by most computer users—serve as active stimuli for at least some LD students and should be used in courseware for them only to evoke desired responses.
No matter what the difficulties faced, students in all three segments used asking for help as their predominant coping strategy. Middle division students were actively encouraged to take this tack: "If you have a problem, ask your teacher," instructed Teacher B early in this group's introduction to the computer. "You were right to come and get me. Any time you have a problem, come and get me," praised the same teacher during an observation session. In fact, these students almost always raised their hands to attract a teacher's attention when they experienced difficulty; frequently, they would leave the computer station at the back of the classroom to walk or run to a teacher for help. Upper division students, too, would call out for help or go to a teacher's desk to ask questions. As the students became more comfortable with the presence of the researcher, they began to direct their questions to her. Students would also occasionally enlist the advice of other students who happened to be nearby when questions arose, and one girl quite capable of proceeding on her own coquettishly asked her boyfriend to help her get into a program "because it's a new thing and I need help getting used to it." Students would also read procedures aloud, often at teacher insistence; upper division students in particular would try to figure things out and ask for assistance only if their initial explorations failed.
In classes as small as those at Marburn, asking for help seemed a natural and effective strategy. In other situations, however, this heavy reliance on teacher (or other adult) assistance would be totally infeasible. In any case, as discussed in Chapter IV, courseware that students could access more independently would be an improvement over packages necessitating extensive teacher intervention at a basic, procedural level. While LD students' reading difficulties make writing any kind of instructions for this group a challenge, designers should be careful to make getting into programs as simple and straightforward as possible.

Not surprisingly, the students who participated in the study had an almost universal disdain for reading courseware directions. When instructed to read them, students in both divisions would, of course, do so: middle division students in particular were routinely told to read instructions by teachers who stood by as described in Chapter IV. Left to their own, however, students in all three groups preferred to avoid instructions and to figure out for themselves what a program required them to do. "It's easier to figure it out [than to read the directions]," argued one middle division boy; the directions are "too long and retarded," asserted another. "I can't understand the directions; I can understand by
finding out," admitted an upper division boy; other upper division students also spoke of the ease or fun of finding out on their own. One student's summary lament about courseware directions seemed to encapsulate the general view: "They're just too confusing sometimes."

Students offered a number of excuses for avoiding directions, even on their first encounters with programs: they had done the program before (even when they knew they hadn't), they had done something like it, they had seen others do it, they simply assumed they understood what to do: "I've done problem solving before," announced one middle division boy who tried to start in the middle of a program that his predecessor at the computer had not finished. When he realized he was unable to do this particular problem-solving task, he--like several others working in a variety of programs--returned to the directions as a last resort.

In fact, however, many students seemed to avoid directions because they didn't expect to learn from them and simply wanted to avoid a useless and onerous task. Even when students did read directions and, in response to the researcher's questions, pronounced them clear and well written, their performances or questions about how to perform clearly revealed a lack of understanding of what they had read. One upper division student described the
situation this way: "Well, they’re well written but I don’t understand what they’re trying to tell you." A middle division student used these similar--and telling--terms: "Well, I understood them. But when I get to the [practice] questions, I don’t understand this."

Students brought a variety of strategies to the task of deciphering courseware requirements. At teacher insistence, they often enhanced the stimulus of words on a screen by reading directions aloud; mirroring a teacher strategy described in Chapter IV, several pointed to words or lines as they read. Several students talked themselves through directions ("Oh . . . OK") and a number asked the teacher or researcher for explanations. While most students routinely skipped over directions for their second and subsequent uses of programs, several actually chose to read (or page through) directions even though they had used a program before or had recently been instructed in its use. While the reasons for this were not always apparent, one boy certainly spoke for at least some of his peers when he confided that he always chose the directions option in order to waste time.

Students encountered a number of general and specific difficulties in interacting with verbal content in various courseware packages. Although most of these were made manifest through students’ responses and are therefore
discussed in the next section of this report, several deserve mention here because they can be separated from responses and treated more generally as characteristics of stimuli that should be avoided in materials designed for LD students. Nonsense or foreign words, for example, caused difficulties whenever they appeared. And high reading and conceptual levels made some courseware simply too difficult for the student participants in this study to understand.

In general, students responded to difficult verbal content as they had to difficult procedures and directions: by asking for help and/or channeling the information through multiple senses by pointing to it or reading it aloud. Two middle division students actually called for silence so that they could concentrate as they read paragraphs, answered questions about them, and tried to move ahead in a reading game.

Students' most interesting strategy for dealing with difficult verbal content, however, involved various mechanisms for avoiding it. Several students tried to read content selectively—attending only to the parts of displays they felt contained information vital to their success with programs. One middle division boy simply paged through display after display of text—apparently concluding that none of it was vital to him. Two others, working independently in the same problem-solving exercise,
chose to ignore one of the two variables they had been given to work with in order to proceed through the program on their own terms. Upper division students, too, coped with difficult reading or content by avoiding it. One boy, having tried unsuccessfully to master a consumer education program ("It's not hard to read but it's hard to understand") finally announced, "We're resetting" and chose another program. Another boy, unable to read a language arts mystery program, juxtaposed three sentences in a telling illustration of a number of LD students' responses to materials that are too difficult for them to read: "I need help. I don't want to play this any more. It's boring." He got up, walked to another learning center to talk to some friends, and came back to the computer to hit the combination of keys he knew would give him a repetitive beep.

The difficulties with procedures, directions, and content encountered by students in all three segments of this study suggest that reading levels in currently available courseware are a serious and continuing problem for students like those at Marburn. This theme will be developed in the next section of this report as well, since students' language difficulties often interfered with their abilities to respond to various programs. While there is nothing new in the finding that LD students experience
severe reading problems, CBE—through the technology of speech synthesis—is in a unique position to circumvent such difficulties. A number of students, in fact, suggested that speech be incorporated into courseware. The findings of this study suggest that, for this population, speech could be used profitably to augment all verbal aspects of courseware, from introductory procedures through feedback and reinforcement. As the technology for providing speech synthesis continues to improve in quality and decrease in cost, instructional designers should make every effort to incorporate spoken presentations into special education courseware.

**Numeric.** Even though math courseware was used far more extensively at Marburn than courseware based on reading, students in all three study segments encountered far fewer problems with numeric stimuli. Only two students, in fact, were observed to have difficulties with numbers, per se, as elements of the stimulus: a middle division girl was unable to do problems presented in a horizontal format until her teacher rewrote one on the chalkboard in the vertical form she understood; a middle division boy complained that "It’s kinda hard when they’re that way. . . . Straight across" but was able to do the problems without teacher intervention.
A number of students actually negated the prevalent belief that frequent changes in the format of stimuli are difficult for LD children to accommodate. Students in both divisions, for example, sometimes expressed surprise but rarely gave evidence of difficulty in switching from one mathematical operation to another. On the contrary, students seemed to enjoy the variety that working different kinds of problems entailed. One upper division boy, after having done approximately 40 addition problems in a decimals program, sighed "Finally!" at the beginning of a new section. His response to a probe about this reaction was a matter-of-fact "Because we did so many addings and now it's subtraction." An upper division girl, asked in an interview whether she thought it was difficult to switch from one kind of problem to another, protested, "I like that. It's one of the things I like."

As they did with verbal stimuli, students in all three segments of the study accentuated their focus on numeric stimuli by pointing to them. Several students also said the elements of problems aloud, enhancing the visual stimulus with the aural. In general, however, the numeric stimuli in the courseware used during this study seemed to present so few difficulties for participating students that little improvement is necessary. Only one suggestion—including an option to allow teachers to choose a vertical
or horizontal format for presenting problems at basic levels—seems warranted.

Graphics/sound. Students in both divisions seemed surprisingly aware of the presence or absence of sound in programs. One middle division boy, for example, "conducted" the electronic music that introduced a courseware package; a middle division girl played with her fingers until the disk drive stopped whirring—signalling her that it was time to begin to work. One boy complained about the lack of sound to accompany the graphics in one program, and several others were fascinated by their ability to create repeated beeps. One boy suggested to several others that they press a particular series of keys within a program to hear Mary Had a Little Lamb.

Tones were effective signals to students about errors they had made and about changes in program demands. Indeed, students expected tones in programs: they made errors, missed changes in displays, and failed to understand feedback when they didn't hear anticipated tones or encountered programs that did not include them. One middle division boy used tones in an especially ingenious way: initially startled by a beep signalling that he had run out of time for his first of two chances to solve an addition problem, he seemed to use the tone in subsequent problems as a signal that his time was only half gone.
Sound occurred infrequently in the courseware used during this study, but students' acute sensitivity to it suggests that designers should consider incorporating it more extensively into CBE packages. In particular, tones to accompany visual enhancement of stimuli might prove very helpful to students, particularly LD ones. One upper division student, for example, seemed to need a stronger cue than the one provided by a simple box that surrounded a target concept: Teacher A had to point to the box and explain its significance. A tone accompanying the flashing of that box might have enabled the student to grasp this significance on his own.

Any sound or graphic embellishments, however, must be used with balance and care in order to avoid students' inappropriate fixation on them. A program used by the upper division illustrates a problem with such fixation encountered in several packages. One of the options in this program allowed students to make simulated telephone calls—emitting "touch-tone" sounds when students hit the number keys and "ringing" until someone "answered" and the program reverted to a visual format. Not surprisingly, students persisted in selecting this option, whether it was the appropriate choice or not. "The first thing I'm gonna do is make a phone call," announced one boy as he sat down to work with the program—clearly not considering anything
but the appeal of this option over its rather dull alternative, reading a simulated teletype.

Students in the study often found graphics distracting: a number of upper division students, for example—particularly those who were most intrigued by programming and by computer technology in general—tended to concentrate on the animated graphics in one program rather than on the concepts these were designed to reinforce. And middle division students working in programs designed to make them aware of visual similarities and differences frequently seemed lost amid the colors and designs they were supposed to distinguish—particularly in the more advanced levels that contained fuller, more detailed screens. Asked if she liked such a program that was clearly giving her trouble, one girl responded, "Yeah. Once I get the hang of it I will."

Alternatively, however, students seemed quite adept at discerning some visual patterns. For example, although several students remarked that the display for a very detailed math game was "confusing," others apprehended its pattern far more quickly than the adults who were observing their progress. Similarly, students using an electronic version of a board game seemed automatically able to keep track of one another's relative positions on the overall "board"—which appeared in miniature on a split screen—and
enjoyed arguing about who was going to leave whom in the dust.

Students did, however, encounter specific difficulties with visual stimuli that should be of interest to instructional designers. A number of middle division students, for example, seemed plagued by a kind of "tunneling"—seeing only the possibilities in the center of displays and being less aware of visual stimuli around the edges. Several boys using a problem-solving program, for example, quickly identified the diagonals in a figure that were in the middle of the display but took considerably longer (and generally needed help) to identify the ones closer to the figure's sides. Similarly, students using a pregraphing program identified coordinates in the center of the grid more quickly than they named the ones around the edges. While the implications of this tendency are unclear in terms of instructional design, designers should at least be aware of this proclivity among a number of LD students.

Motivation. The program used most extensively during the study was—by the admission of the teachers who implemented it—instructionally helpful but "not very motivating. " Students concurred in their teachers' assessment: "That doesn't catch your eye," explained one. "It's sorta dull." Similar lacks of motivational aspects are a serious problem in a number of courseware packages—
particularly for students who are used to the game programs they play at home and who expect courseware to be as captivating and exciting as whatever computer games are currently in vogue.

Students' predominant strategy for coping with unmotivating courseware was simply to make it motivating. And almost invariably, students' attempts to augment motivation involved introducing competition. Time and time again, students increased their own interest in straightforward programs by drawing on a repertoire of competitive elements. They taunted each other with expressions of superiority: Student 1: "Don't worry--I'm good at this." Student 2: "I'm better." They found ways to compete that were unintended--and in some cases guarded against--by program designers: "He's only on 22?" asked a girl rhetorically while checking a classmate's private folder. They talked themselves through lessons as if they were engaged in Olympic contests: "These problems think they're smarter than I am. Who do they think they are? They're not smarter than me." They questioned each other about who got the greater number of problems correct: "A hundred. . . . Betcha a dollar." They made sure others did not get the chance to finish extra assignments: "Nobody's supposed to be ahead of me." They accessed successive levels in a program through the management system rather
than directly so they could record additional perfect scores.

Not surprisingly, then, students responded enthusiastically to courseware that incorporated competition through game formats. In fact, only one student who used such programs responded negatively: "That's not multiplication," announced the dissenter when he saw the invading space bodies he was supposed to shoot down with the answers to problems; "I want real multiplication." Even he, however, was thoroughly engaged in the program once he started it--cheering himself on ("Oh, brother! Oh, brother!" "Fire!") and amassing a respectable score. Another middle division student--a girl who often seemed oblivious to such things as winning and keeping progress records--also enjoyed firing at tanks and at meteors, although she was clearly less concerned with finding the correct answer than with enjoying "the way the thing goes around and blasts those numbers."

For many students, the competition with themselves and others included in game or gamelike programs was actually insufficient. These students, once they had mastered the basics, invented goals for themselves that exceeded those established by the courseware designers: the goal among a group of upper division boys using a series of math games soon became getting scores higher than 100. The goal in a
spelling game became identifying the target word without any errors so that the gate that closed in increments for every letter guessed incorrectly would never begin to drop. Middle division students, too, augmented the competition inherent in various programs: one boy tried to identify correct spelling words before the timing device associated with the program—a bar that made its way across the bottom of the display and changed colors from green to red to white as response time passed—even began to appear. Another boy, working in the same program, tried to type words as fast as he could ("How's that for fastness?") even though the program's timing mechanism was not in effect for this part of the program.

Illustrations like these of students' positive responses to competition are legion. In fact, as discussed in the following segments of this report, the power of competition persisted through students' interactions with courseware responses and reinforcement as well. While it is true, as Teacher B suggested, that much of what comes across as competition is a reflection of students' working to improve their self-concepts, it is also undeniable that competition with self and against others is a very powerful motivating device.

The question of competition in the classroom is, of course, a delicate one; and it would be a mistake to
conclude that the students in this study were always gracious competitors: several deliberately withheld information from opponents or became obnoxious enough in their attempts to beat one another that they drew teachers' reprimands. Nevertheless, one of the most broadly based findings of this study is that students find competition extremely motivating. Accepting this fact and dealing with it positively, creatively, and in ways that subordinate gaming dimensions to the learning they are supposed to enhance are important challenges for instructional designers.

In summary, Table 8 reveals a great deal about the stimulus characteristics of courseware with which students in this study interacted: that reading of any kind—computer procedures, courseware directions, and courseware content—was a serious and pervasive problem; that switching from one stimulus format to another, at least in math, did not seem to be; that sound had a primacy that suggests it could be used more effectively in many programs; that students were sophisticated about some kinds of graphics displays but confused or distracted by others; and that competition was an extraordinarily powerful motivator.

Similarly, the table reveals that students had a repertoire of strategies for interacting with each of these
kinds of characteristics and that many of these strategies involved augmenting visual stimuli by channeling them through other senses. Students' tendency observed throughout this study to try to avoid reading (even though, as one boy noted, reading on the computer is "a lot better than in books") is not surprising, since it reflects human nature in general as well as the particular difficulties characteristic of many LD students. Students' efforts to enhance the motivational aspects of dull courseware are also not surprising, since many of the students are well aware of other computer packages that are far more exciting than the typical drill and practice programs used in schools.

The provision of verbal material through speech synthesis—a recommendation of many study participants—is one way instructional design could alleviate the reading problem and thus enable students to interact with courseware more independently. Indeed, the lack of student independence described here and in Chapter IV is a widespread and serious problem that attenuates the potential of CBE for students like those at Marburn. Since such independence is a goal of special education—and a frequently touted advantage of CBE—measures for enhancing it through the unique capabilities of the computer should
certainly be considered to counteract the serious lack of this quality observed throughout this study.

**Students and Responses--Conceptual Demands**

Table 9, "Students and Response Characteristics--Conceptual Demands," presents the findings of the study about the ways in which students interacted conceptually with questions in various kinds of CBE courseware. This table, more than any other in this chapter, reflects the differences in the kinds of courseware used with the three groups of students who participated in the study and therefore highlights the differences in the natures of their interactions with CBE.

**Verbal.** In the verbal domain, for example, both the problems and strategies middle division students displayed stemmed from the fact that these students used two very different types of "verbal" courseware: a spelling drill and practice program and a game based on reading comprehension. Responding in the spelling program--which presented a series of sentences, each with a blank and a three-option multiple-choice answer for filling in the blank--students frequently chose wrong homonyms or selected wrong answers because of difficulty reading the sentences. "Your/you're," "its/it's," and "there/their/they’re" seemed to cause difficulties for several students; one boy, in an
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<th>STUDENTS CHARACTERISTIC</th>
<th>PROBLEM</th>
<th>STRATEGY</th>
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<tbody>
<tr>
<td>Middle division Verbal</td>
<td>wrong homonym</td>
<td>match to sample</td>
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<td></td>
<td>unfamiliar words</td>
<td>avoid reading</td>
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<td></td>
<td>typing errors</td>
<td>guess</td>
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<td></td>
<td>looking at screen, not keys</td>
<td>ask teacher or researcher</td>
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<td></td>
<td>general reading difficulties*</td>
<td>say letters aloud+</td>
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<td></td>
<td></td>
<td>sound out possibilities+</td>
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<td></td>
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<td>try vowels first+</td>
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<td>Numeric</td>
<td>right-to-left entry</td>
<td>count on fingers</td>
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<td></td>
<td>wrong operation</td>
<td>use regrouping option</td>
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<td></td>
<td>lack of gaming skills</td>
<td>use gaming skills</td>
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<td></td>
<td>reversals</td>
<td>talk self through</td>
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<td></td>
<td>confusion about regrouping function</td>
<td>guess</td>
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<td></td>
<td>lack of knowledge</td>
<td>let time run out</td>
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<td>escape</td>
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<td></td>
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<td>use &quot;air scrap&quot;</td>
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<td></td>
<td></td>
<td>use scrap paper*</td>
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<tr>
<td>Graphic</td>
<td>failure to see pattern</td>
<td>focus on extraneous cues</td>
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<td></td>
<td>failure to understand task</td>
<td>experiment/figure out</td>
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<td>same/different confusion</td>
<td>talk self through</td>
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<td>guess</td>
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<td>use elimination strategy*</td>
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<td></td>
<td>ask teacher or researcher*</td>
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<tr>
<td>Problem solving</td>
<td>too complex</td>
<td>ask teacher or researcher</td>
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<td></td>
<td>failure to understand task</td>
<td>use trial-and-error approach</td>
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<td>avoid practice option</td>
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<td>take notes</td>
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<td>experiment</td>
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<td>terminate</td>
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<td>choose practice option**</td>
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<td>talk self through*</td>
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<td></td>
<td></td>
<td>use systematic approach*</td>
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</tbody>
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*Singular instances within groups repeated in other groups.

+Singular, unrepeated instances of particular significance.
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<thead>
<tr>
<th>STUDENTS CHARACTERISTIC</th>
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<tr>
<td>Upper division</td>
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<tr>
<td>Verbal</td>
<td>failure to understand task</td>
<td>ask teacher or researcher</td>
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<td></td>
<td>general reading difficulties</td>
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<td></td>
<td>spelling difficulties</td>
<td>turn task into game</td>
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<td></td>
<td>difficulty with passive voice</td>
<td>read selectively</td>
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<td></td>
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<td>match to sample</td>
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<td></td>
<td>talk self through*</td>
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<td></td>
<td></td>
<td>use scrap paper*</td>
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<td>Numeric</td>
<td>wrong operation</td>
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<td></td>
<td>lack of attack skills</td>
<td>use scrap paper</td>
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<td>inappropriate use of ruler</td>
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<td>talk self through</td>
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<td>ask teacher or researcher</td>
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<td>use &quot;air scrap&quot;</td>
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<td>use number line</td>
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<td>guess</td>
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<td>adjust controls to buy time</td>
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<td>simplify problems+</td>
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<td>Upper division</td>
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<td>Verbal</td>
<td>failure to understand task</td>
<td>guess</td>
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<td></td>
<td>general reading difficulties</td>
<td>count number of letters</td>
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<tr>
<td></td>
<td>spelling difficulties</td>
<td>refer to book(s)</td>
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<td></td>
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<td>turn task into game</td>
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<td>use elimination strategy</td>
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<td>ask teacher or researcher</td>
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<td>Numeric</td>
<td>failure to understand task</td>
<td>use regrouping function</td>
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<td>confusion about regrouping function</td>
<td>talk self through</td>
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<td>lack of knowledge</td>
<td>use gaming skills</td>
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<td>experiment/figure out</td>
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<td>use &quot;air scrap&quot;*</td>
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<td>use scrap paper*</td>
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<td>refer to notes*</td>
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<td>escape*</td>
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<td>Problem solving</td>
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<td>use trial-and-error approach</td>
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<td>use systematic approach</td>
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*Singular instances within groups repeated in other groups.

+Singular, unrepeated instances of particular significance.
interesting but singular error that might have been avoided if the stem had not focused on the sense of sight, chose "eye" rather than "I" to complete this sentence: "When can ___ see the picture?"

Several students blamed their errors on not being able to read the sentences that provided the context for the words: "That happens all the time when I can’t understand the sentence," remarked one girl; "What’s that word?" demanded another as she tried to determine which spelling to choose. Students made errors when they looked at the screen rather than the number keys they were supposed to be pressing to make the correct word choices; they also had a number of problems during the second phase of the response requirement for this program, which called for them to type in the correct spelling of each word.

Almost all the students who used the program developed a strategy for approaching this typing task. Looking carefully from the screen to the keyboard and back again, they matched their typing to the correct spelling, which was boxed in the center of the display. Although few students used this match-to-sample strategy consistently—and many made errors when they forgot to check their work at the ends of words—all who used it developed it independently and without instruction. Not surprisingly, students also guessed at answers ("I didn’t know any of the
words, so I just took a guess") and asked the teacher or researcher for help. One girl talked herself through parts of the drill, announcing the numbers of the words she would choose; one boy said the letters of the words aloud as he typed.

The most interesting strategies for responding to spelling courseware, however, were developed by a boy using a different package—one including several gamelike programs requiring the user either to unscramble the letters of each target word or to identify and spell it on the basis of the number of letters it contained. This boy, who was the most advanced of the middle division students, sounded out the possibilities of the scrambled words component of the package and guessed vowels first when he tried to identify the "mystery words": "I just thought so I could get rid of 'em. Every word has a vowel in it, so I thought I'd try that." Both strategies enabled the boy to respond successfully to the courseware, although an overuse of the latter approach—for example, guessing two vowels, a consonant, and then the three remaining vowels for a four-letter word whose first two letters were "e" and "a"—suggested an inefficient use of a generally helpful approach.

In the reading comprehension program, students played an electronic board game in which they could advance either
by luck or by answering three-option multiple choice questions about the main ideas in paragraphs on spaces on which they "landed." Although the students performed quite well in the game—in one session the six players got 14 correct answers and missed only 2—the reading difficulties (as described in the discussion of students' interactions with stimuli) interfered with their enjoyment of the game and with their ability to respond as well. Students complained loudly about the ratio of paragraphs to chance moves: "It takes so long! They should cancel the [paragraphs]," recommended one boy; "Oh, man! Not another dumb question," groaned a classmate a few minutes later. Even though the students knew that answering questions was the quickest way to advance—"I want one of those 'cause that's the only way to catch up"—they discussed bypassing the reading and simply guessing the answer or reading only the three choices and picking the most likely alternative. While some students continued to read, others did in fact simply guess—with some degree of success: "Oh gosh! I got the hypothesize correct," announced a boy who was one of several students trying out some new vocabulary from science class. "I never read it, either," he continued.

Some Phase 2 students also used this program and, like the younger ones, had a variety of difficulties reading the paragraphs and making correct responses: these students
stumbled through paragraphs and chose incorrect answers, stumbled through and chose correct answers, and read with apparent fluency and chose incorrect answers. Students in this group also used the gamelike spelling package described above but failed to develop any sophisticated strategies for identifying the "mystery words": working as a group on words from their current spelling lesson that had been entered in the program by their teacher, these students merely counted the number of letters in each word and then tried to guess the first, second, and so on letters of the word until they had identified it. At the teacher's suggestion, they referred to their spelling books to help them remember the possibilities. Using the book also led one boy to try a strategy of elimination—"It's the only one we didn't have"—which the others adopted immediately. Upon hearing a description of the younger student's approach of trying vowels first, this group's teacher expressed doubts that these students would come up with such an approach on their own: "They don't have any strategies for spelling." The suggestion of using the package to help students develop such strategies would obviously be a valuable addition to the courseware documentation.

Phase 2 students did invent a strategy that enabled them to cope with a program whose content they simply did
not understand. Supposed to assign ratings to each of three campaign factors for each of two presidential candidates, all three pairs of students who used this program quickly turned it into a math drill and practice exercise and one pair turned it into a game as well. As soon as the program informed them that "The three numbers must total 100," the students stopped weighing reasons for their ratings and assigned numbers at random--concerned only that the last of the three bring the final score to 100. The pair that turned the program into a game altered their combination of ratings for one set of candidates seven times so that their favorite could beat the winner that had been predetermined by the program. "This is fun," announced one of the pair--who spent 12 tries and 23 minutes at a task they simply did not understand.

Phase 1 students also encountered verbal tasks they failed to understand and responded by turning the program in question into a game. Three boys were sent to the computer room independently to explore a program designed to teach money management skills; all three focused not on spending money wisely but on "winning" a game that was not, in fact, part of the courseware package: "I got 'no bills' twice," announced one boy, apparently having concluded that this achievement constituted victory; another, spending only $65.87 of his $70 food allotment--but getting a very
low "efficiency rating" because of his poor choices—was so pleased that he didn't overspend that he went to look for a pencil to write down his "score" and show it to his teacher; and the third, after complaining repeatedly about the quality of "this game," engaged in a dialogue with the researcher that clearly reflected his assumption that courseware is gameware and reinforced the finding about the introduction of competition into noncompetitive programs discussed in the preceding segment of this chapter:

Researcher: What would you say if I told you it's not a game?
Student (with obvious surprise): What is it?
R: You're supposed to learn something from it.
S: You don't. Write that down.
R: You're supposed to learn how to spend your money wisely. . . .

Courseware like this package and the one described just above it allows students to perform individual tasks without understanding the purpose of the program and without learning from it. This problem seemed to arise in a number of packages observed during this study—verbal, numeric, graphic, and problem solving. It is a serious instructional design problem, and one that deserves considerable attention. Students' apparently automatic tendency to make games of programs they don't understand seems a reasonable, if lamentable, approach to such courseware. Obviously, designers should take care—for
example, through the provision of mechanisms that prevent students from moving on unless their responses are appropriate—to minimize the use of this strategy.

Students also employed other strategies to deal with difficulties related to verbal responses. Students in all three segments, for example, followed the familiar pattern of asking a teacher or the researcher for help; this approach was especially helpful in one program, whose requirement that students respond in the passive voice seemed insurmountable to at least one student. Students in both divisions talked themselves through their responses, and Phase 1 students both used the match-to-sample strategy to alleviate spelling difficulties and read selectively as described earlier in this chapter. One student used scrap paper to take a few notes about the consumer education program, but the strategy was not helpful and he abandoned it almost immediately.

As they do with verbal stimuli, instructional designers have a number of options for helping students overcome reading difficulties in making correct responses. Presenting response contexts and options through speech synthesis and simple, straightforward language is an obvious first step. In addition, providing clear statements of goals and objectives as well as suggesting strategies for achieving these would enable students to
Numeric. Most of the courseware in use during the fieldwork involved math drill and practice, and students encountered a variety of difficulties in responding in this domain and developed an array of strategies to counter these problems. One of the most interesting series of observations in this area involved middle division students and the subtraction component of the math program that was used more than any other courseware at the site. This component requires students to enter answers of two or more digits from right to left—a requirement that initially confused almost every student who used the program: "You have to write it backwards. You're supposed to write it forward but they make you write it backwards," complained one girl. First with teacher assistance, however, and then on their own, students adjusted to this requirement almost immediately, only occasionally trying to enter answers from left to right after their early uses of the program and then always able to correct themselves without difficulty.

After using only this math program for approximately a month, students were switched to some others designed to accept left-to-right entries—and had virtually no problems adjusting to the new format, even though they had not been told about the change. Only two students were observed to
have any difficulty--one girl who recognized and corrected her own mistake ("Oops!") and one who required adult intervention to see what was happening: "Oh! I just mixed 'em around." Briefly returning to the initial program after the Christmas break, only one student--the girl who had needed assistance earlier--was observed to need a reminder from the teacher to "enter the number for the ones column first."

While it is encouraging to observe that most students were able to make such adjustments independently and with little apparent difficulty, the fact that different packages on the market require such adaptability should be noted. Particularly for students prone to reversals, switching back and forth between such different patterns could be extremely confusing. Once again, documentation should clearly specify the response pattern required so that teachers can be aware that some preparation of their students might be advisable.

Another interesting problem, and one that occurred in both divisions, involved students' uses of the wrong operations to get their answers. Occasionally, these wrong operations resulted from simple misreadings of mathematical signs: "I was thinking plus [rather than times]," explained one boy after making such a mistake. At other times, however, this problem involved students' using
simpler operations than those supposedly required by the program: counting from one number to another rather than adding to get their total (e.g., responding to 8 + 5 by saying, "8, 9, 10, 11, 12, 13"); adding by increments rather than multiplying (e.g., responding "3, 6, 9, 12" for 4 X 3); adding the lengths of sides to get perimeters— or even trying to measure all four sides of a square— rather than using the formula for which the problems were intended to provide practice. Both a problem and a strategy, this approach enabled students to obtain the answers sought by the programs— but it militated against their learning what the programs purported to teach. Programs that anticipate students' tendencies to oversimplify tasks and that require students to perform the operations within the program rather than in their heads or on scrap paper could alleviate some of this difficulty.

A similar situation existed for a number of upper division students who had difficulty with a program drilling on the commutative and associative laws of addition. After their initial difficulty with these rather complex concepts, all the students eventually found a simple way to complete the exercise. As one boy explained, "These are so easy. You just put the number. All you do is there's a 2 over there so it must be a 2." The boy and his counterparts ultimately sped through problems simply by
finding the number on one side of the equation that was missing from the other and plugging it in. Students rapidly did 30 and 40 problems at a sitting without ever thinking about the difficult concepts involved--and, apparently, without understanding that their simple responses did, in fact, illustrate those concepts. The program, of course, allowed this kind of response; requiring students to build one side of an equation to illustrate a particular law would be a clear improvement over this approach.

Students in both divisions made mistakes because they had difficulty remembering their math facts ("I don't know my 8s and 9s," confided one upper division boy who was having difficulty with multiplication) and because the regrouping option offered by one program caused occasional confusion ("'cause you think you're putting your answer down and you're only carrying it over"). Several middle division students consistently reversed the X and Y variables when plotting coordinates in a pregraphing program, and several upper division boys lacked attack skills for reducing fractions. One boy's problems were exacerbated by the program he was using, which flashed a question mark where the student was to enter the reduced numerator--apparently assuming the respondent would reduce the entire fraction mentally or on scrap paper before
entering any part of the answer. This student, however, simply "reduced" the numerator as far as he could and never considered the denominator. When the researcher tried to help him out of his dilemma, he asked: "Why do they start you up here if you gotta look at the bottom one?" Once again, courseware that requires students to perform their calculations within the program would alleviate such problems.

Lack of gaming skills inhibited the success of a few students in each division when they first used programs requiring them to "shoot down" invading entities with the correct answers to simple math problems. The majority of students who used these programs, however, developed a number of sophisticated strategies on their own: using consistent, efficient response patterns; going after the invader most likely to crash and end the round; saving time by answering all the problems with the same answer rather than rekeying the number several times; skipping problems they could not answer immediately and returning to them at the end of a round. Several older students in particular revealed themselves to be excellent gamers with sophisticated timing skills and "shooting" strategies.

By far the most widespread strategy for responding in math programs, however, involved various methods of counting. Students counted by folding their fingers into
their hands, by counting the fingers of one hand with those of the other, by using the keyboard keys as a counting aid, by tapping out beats on the computer table or console, and by drawing hash marks on scrap paper. The middle division students, not surprisingly, used counting strategies far more extensively than the upper division ones—but some older students used their fingers even for such simple problems as $7 - 3$. One middle division girl had an entire repertoire of counting strategies: in addition to using almost all the variations noted above, during one observation session she moved her finger from left to right and top to bottom on the screen to count the "points" on second digits in such problems as $8 + 4$; during another session, she used a particularly ingenious strategy—starting at the "0" key and counting backwards the number of keys in the subtrahend until landing on the answers to several problems with minuends of 10.

Neither consistent/experienced teacher who participated in the study had qualms about students' counting strategies. Teacher A preferred that students use scrap paper "because I think it's just real important to be . . . sure of [the answer before entering it because] some of the computer programs--they don't give you the second chance" but did not discourage counting on fingers because "some of [the students] just don't have the memory to
memorize all the facts." Teacher B held similar views—"I like them using their fingers as long as they realize that that is a crutch and if they need to use it, fine"—and expressed concerns about courseware that requires students to respond so quickly that they cannot use this strategy that seems to work so well.

Students made extensive use of the regrouping function offered by one program. Presented as an option for subtraction problems of almost every level of difficulty, this function allowed students to use the spacebar to draw slash(es) through the second-, third-, and fourth-place digits of original minuends and to carry numbers to the ones, tens, and hundreds columns. A useful tool that both enabled students to complete difficult problems and reinforced their awareness of correct processes, the option had some attendant problems as well. Students who chose it, for example, tended to use it for every problem rather than selectively—failing to develop not only their own subtraction skills but also higher-level skills that would allow them to monitor their learning needs. Students also tended to use the option even for such simple problems as 30 - 29 and 11 - 2, thereby missing an opportunity to see such problems as a whole and to develop an understanding of mathematics beyond a mere procedural one. Neither consistent/experienced teacher in the study was concerned
about these issues, however; both felt that the option's reinforcement of correct process was of paramount importance for LD children, who are characterized by difficulties in processing.

In responding to math courseware, students used several of the same strategies they adopted for verbal responses—talking themselves through problems, guessing, and asking the teacher or researcher for help—and a few that were more specific to mathematics: using a number line to work with positive and negative integers, using scrap paper, and letting time run out for problems they knew they could not answer. Several students adjusted the controls on the monitor to buy time when they did not know answers immediately, and one volunteered an explanation of a rather sophisticated strategy of simplifying problems by performing operations on the smaller numbers of an equation before tackling the larger ones. Several students chose to escape from programs and begin them again when they made mistakes and realized they could not get perfect scores, and one upper division girl referred to her notes in an attempt to understand the laws of arithmetic sequence described above.

Among the most interesting of students' strategies for dealing with the responses required in math courseware, however, were some students' use of the space in front of
the computer screen as "air scrap" and others' use of the problems themselves as vehicles for learning how to make the required responses. A number of students used the former strategy—skillfully solving problems with their index fingers in a way that suggested the efficacy of such a tactile approach. One Phase 1 boy, for example, "rewrote" problems from a horizontal to a vertical format and carried numbers from one column to another by marking out the air in front of the originals and rewriting the regrouped ones in the air above them. A Phase 2 boy "moved" decimals in the problems he was dividing by drawing little scoops below the dividend—but in the air.

The most illustrative example of the latter strategy—using the problems in a learning-to-learn strategy for determining the expected response—was provided by a Phase 2 boy who took this tack several times. Doing poorly enough in one segment to be branched to the preceding one, he then went through both segments without error. "I figured it out when I was doing [the first segment]" he explained after one such instance. "I figured out how to do it." This strategy may not be efficient—and it plays havoc with students' scores in programs that automatically record numbers correct—but it seemed to be effective for at least some of the students in the study.
As with numeric stimuli, numeric responses—which, at least at the basic levels observed during this study, are by nature more direct and straightforward than verbal ones—caused relatively few problems for participating students. Indeed, students seemed to have developed more successful strategies for responding in this domain than in any other. The response aspect of numeric courseware could still be improved, however, chiefly by having students perform all necessary mathematical operations within the courseware and thus ensuring that students’ experiences at the computer truly reinforce their understanding of target concepts.

**Graphic.** Only the middle division students used graphics based courseware: one program designed to help them differentiate between similarities and differences and another—a pregraphing program—to teach them to use mathematical coordinates to create pictures. Students who used the latter program sometimes had difficulty seeing emerging patterns ("How does that end up a clown? I don’t understand, quite") while students who used the former had a number of difficulties distinguishing between pairs of colors, heights, sizes, and shapes.

A number of students who used this program had serious difficulties with it, apparently either failing to understand what they were supposed to do and/or finding it
much easier to concentrate on differences than on similarities—even when identity was the target concept. The girl who used the program most extensively, for example, consistently made figures differ on a number of traits, even after choosing the program option in which she was to make the figures match. Her response to the problem-solving segment of the program—which required students to derive rules for membership in a club based on similarities among figures—illustrated the difficulties all students who used this program had with its most complex dimension: "I'm gonna guess this rule if it takes all day," she announced—proceeding to guess trait after trait until she happened upon the rule rather than trying to determine that rule by studying what members had in common.

Most students' strategies for coping with graphics based responses were similar to those described for the verbal and numeric domains, although two new approaches surfaced with this kind of courseware as well. Several students, for example, focused on extraneous cues—"Three is always different"—an approach that, by chance, yielded some degree of success. One girl verbalized an elimination strategy ("It's not short. It's not thin") that she used for several rounds until she had fixed the differentiating traits in her mind. Then she simply went directly to the
correct alternative, demonstrating the efficacy of this approach.

While it is evident that students encountered difficulties responding to graphics based courseware, it is less evident how instructional design might alleviate such problems. Simplifying the tasks would often undermine the target concepts, and reducing the visual complexity of the displays would often have a similar effect. In any case, designers need to be aware that the perceptual problems of many LD students seem to lead to difficulties responding in the graphics domain.

**Problem solving.** As noted in Chapter IV, problem solving is considered an important content area at Marburn; not surprisingly, then, two of the three segments of students in the study experimented with problem-solving courseware during the fieldwork. The problems students encountered with the various packages in use—failure to understand the task at hand and inability to perform at a level of complexity that would seem to prevent many students, not only LD ones, from using such courseware—are indeed significant. Far more interesting, however, are the strategies students developed to cope with their difficulties.

Some of these strategies are familiar: asking for help, taking notes, experimenting until discovering what to
do, and terminating or escaping when there seems no possibility of success. But several additional strategies came into play when students interacted with problem-solving courseware, and even some of the familiar approaches took on new aspects in this content domain.

A number of upper division students, for example, were almost forced to choose the "escape" option in the problem-solving program they used because the program simply presents problems and offers no hints about how to solve them. The package requires users to move various amounts of liquid among storage vats and a tanker in order to arrive at total amounts specified in the program. Based upon one-stroke responses that enable students to perform graphically interesting tasks with ease, the package provides no guidance about how to reach the goal of those tasks. Indeed, although the purpose of the program is to solve each problem in the fewest tries, that target number is never even made available to students, who thus have no way of gauging the difficulty of a problem or of knowing how efficiently or successfully they are solving it. Consequently, students who did not immediately perceive a correct approach on their own or who did not happen upon one after a few exploratory attempts generally chose to escape rather than aimlessly filling and emptying containers.
A unique but telling case illustrates the consequences of the program's failure to provide learning guidance. One afternoon, an upper division boy took 35 tries to solve a problem that could be solved in 7 and then announced he was going to try a more advanced level "'cause it got easy." The boy had discovered a correct but cumbersome problem-solving algorithm early in this experience, and the failure of the program to point out a more direct approach allowed him to perseverate in his initial strategy without awareness either of its inefficiency or of its absolute failure in terms of the program goals. While the boy obviously gained feelings of mastery from using the program, these feelings were in fact unfounded.

A classic example of the great-graphics-no-instruction genre of courseware, the package thus reinforces an unsystematic approach to problem solving rather than teaching or even shaping systematic methods of reaching solutions. Most students did, in fact, use a trial-and-error approach; several were so enamored of the program's exciting animation that they simply filled and emptied containers with little apparent thought about the problems to be solved.

Several students concluded independently that they could not reach an odd-numbered total with tanks that held even-numbered amounts—a surprisingly sophisticated
insight. Said Teacher A, "I never realized they figured that out. . . . That's super! . . . I didn't teach them that. They did that on their own." Students who were aware of this fact had obviously learned something from the program, in spite of its deficiencies, and were able to use the program's "impossible" solution option effectively.

Two boys who were particularly successful with the program developed systematic strategies of their own, but neither was able to articulate his strategy: the one questioned most closely responded by announcing the results of each step ("I'm gonna fill up number 9. I'm gonna put it in number 8" and so on) rather than describing underlying thought processes. Both boys agreed that they planned their steps in advance ("I try to do it ahead of time before I make a decision about which key to push") but their responses were too vague to yield insights about the precise natures of their thinking.

Middle division students used the problem-solving segment of a package described in the graphics section above and experimented with several other programs primarily to enable the researcher to observe their methods of interacting with this kind of courseware. In these latter programs, only one student developed a truly systematic approach; and only one other student chose the practice option provided in one of the programs. The other
students used a trial-and-error approach or managed to avoid the problem-solving aspect of the programs entirely--performing individual tasks, as described earlier in this chapter, and simply bypassing displays that asked them to derive rules based on those tasks.

Instructional design can do much to enhance the quality of the response characteristics of problem-solving courseware. Most significantly, designers can be sure such programs make instruction explicit rather than merely implied. Information that would enable users not only to understand the nature of each problem to be solved but also to judge when solutions are appropriate is critical to the success of this kind of courseware as an instructional tool. Problem-solving programs that omit such information engender learning only incidentally rather than by design.

In summary, Table 9 reveals that the language problems students experienced (as described for their interactions with verbal stimuli) affected their abilities to respond in this domain as well. Few students developed sophisticated strategies for interacting with verbal responses, although selective reading was effective in some instances. Similarly, the widespread adoption of the match-to-sample strategy in connection with the middle division spelling program suggests that many students can, in fact, develop simple but successful strategies on their own.
The array of strategies students developed for responding in the numeric domain gives further evidence of their ability to interact effectively with response characteristics, although the absence of effective approaches for coping with difficulties with graphic stimuli and for engaging profitably with problem-solving courseware are cause for concern.

For instructional designers, the implications are clear. First, of course, designers should create courseware that avoids some of the more obvious problems—particularly the allowance of individual tasks without consideration of program goals—as described under each of the topics above. Additionally, designers should incorporate suggestions for strategies either into their courseware or into its accompanying documentation. Students cannot be expected to develop effective response strategies on their own, and teachers cannot be expected to know a priori the kinds of approaches that would enhance students' chances of success in particular packages. Responding effectively is, after all, at the heart of learning; courseware could do much to help students acquire successful, transferrable strategies that could be useful not only in their interactions with CBE but also in a number of other learning tasks.
Students and Responses--Procedural Demands

Table 10, "Students and Response Characteristics--Procedural Demands," displays the ways in which students responded to such procedural characteristics of courseware as the provision of hints, keyboarding requirements, and the speed of responses called for in timed exercises. Much of the table is self-explanatory, but several of its themes deserve amplification. One theme—students’ interactions with hints—requires particular attention.

Keyboarding requirements. The vast majority of students in all three segments of the study lacked both knowledge of the keyboard and typing skills. Consequently, programs that required extensive typed responses caused serious difficulties for the students who used them. The problems were particularly evident in the spelling drill and practice program discussed above, which required students to type each word correctly at least once—and words on which they had made errors three times. In this program as well as others that required much simpler responses, middle division students searched painstakingly for each letter: one boy, required to type "did" three times, searched for the "d" each time he needed it—a total of six searches; another had the same difficulties with "high." A third, looking for the single letter he needed to enter a response in another program, provided a running
Table 10
Students and Response Characteristics--Procedural Demands

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<thead>
<tr>
<th>STUDENTS CHARACTERISTIC</th>
<th>PROBLEM</th>
<th>STRATEGY</th>
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<tr>
<td>Middle division</td>
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<td></td>
<td>Hints</td>
<td>failure to respond</td>
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<td>Keyboarding requirements</td>
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<td>lack of typing skill</td>
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<td></td>
<td>Speed requirements</td>
<td>respond incorrectly</td>
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<td>Upper division</td>
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<tr>
<td>(Phase 1)</td>
<td>Hints</td>
<td>failure to respond</td>
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<td>inappropriate response</td>
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<td>Keyboarding requirements</td>
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<td>Upper division</td>
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<td>(Phase 2)</td>
<td>Hints</td>
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<td>failure to understand*</td>
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<td>Keyboarding requirements</td>
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<tr>
<td>Speed requirements</td>
<td>respond incorrectly</td>
<td>complain about fast speed</td>
</tr>
</tbody>
</table>

*Singular instances within groups repeated in other groups.
+Singular, unrepeatable instance of particular significance.
commentary while he searched: "G . . . g . . . . It's hard to find it. Where is it? Right in the middle!" Finding the apostrophe—and using the shift key to enter it—was a particularly trying task for many.

Not surprisingly, the spelling program was not students' favorite: one boy's frustrated outburst—"I hate this typing the word part"—echoes a complaint heard almost universally. While the typing no doubt enhanced students' awareness of particular letters and enabled them to spell successfully without the reversals and smudges that often plague LD children, the use of the QWERTY keyboard was a serious burden for them. Several students, in fact, wondered why keyboards weren't arranged alphabetically—the most vocal spouting in exasperation, "What do you have to learn the alphabet for? The only thing they put in alphabetical order is the dictionary."

Older students generally had similar difficulties when required to enter letters, although at least some of them had acquired a degree of typing skill before the fieldwork began. Students in both divisions developed idiosyncratic—and often quite physically demanding—typing styles that they will one day have to unlearn if they are to become reasonably skilled at keyboard use: one small boy held down the shift key with his left thumb while
hitting the apostrophe with his left index finger—quite a contortionist feat!

All the students were, not surprisingly, more successful typing numbers than letters. Several, as noted in a previous section of this report, became quite skilled at responding to gamelike math courseware—moving into efficient and effective patterns for using various keys to enter answers, position weapons, and fire at various kinds of invaders. Even here, however, students had difficulties: several recommended moving the "0" to the left of the "1" to make responding to math problems physically easier and conceptually more reasonable.

**Speed requirements.** Only two of the three segments included in the table used programs with serious time constraints, and students in both gave timed programs mixed reviews. Although speed was occasionally given as the reason for errors ("I put the wrong thing 'cause I didn't want to run out of time") most students adjusted quickly to working against a clock and became rather adept in using timed programs.

Nevertheless, students in both divisions complained about speed requirements—"It's nerve-wracking, gets me hyper. It's too tiring," said an upper division boy who was actually one of the most skilled gamers. "It doesn't give you enough time to figure out what to do," noted one
middle division girl. "This isn’t easy. . . . you have to
do it fast or it botches you up," complained another.
Students in both divisions also insisted, however, that
they liked timed programs: "'Cause I just like them,"
replied a middle division girl. One of the older girls
offered a more detailed explanation: "I feel it’s more fun
that way because it’s challenging you. You have to try to
get every one on time. . . . you’re challenging your own
reflexes. And how fast you can figure out the problem."

One of the timed programs actually seemed too slow for
the upper division boys who used it: two tried to make it
more interesting by going after its invaders either as soon
as they broke from their source or when they were just
about to crash. One boy spent considerable time with his
hands in his pockets, waiting for the problems to skim the
ground: "Man! I didn’t know how low they could go."

Hints. A number of programs in use during the study
provided hints for students to use in determining and
entering responses. Almost none of the students, however,
used these hints effectively. Students would simply fail
to respond to hints—suggesting by their comments and
questions that they were unaware of the existence or
function of these aids. One middle division boy, for
example, didn’t realize that a hint appeared on every
display to help him draw the clown pattern he failed to see
emerge. Another explained that it was a good thing he had memorized the keys he needed to work a particular problem-solving program—even though the keys appeared in a small drawing in a corner of every display. Students were routinely surprised when the spelling program would not advance because they had failed to notice or respond to its instructions to "Please type the word again." Several students, as noted earlier, went directly to "Press return" lines—avoiding hints that were sometimes as close as a double space above.

Upper division students, too, failed to notice and/or use hints. The math program they used most extensively, for example, provided an excellent hint by showing a short blank line for each digit (including, if applicable, a line for a plus or minus sign) in the answers students were supposed to enter. Questioned about their awareness of this hint, several students looked closely at the screen but failed to see it. One boy, who claimed that he used the hint and that he had "noticed it on my own," showed a failure to use it consistently in a question he asked just moments after making the claim noted above: apparently oblivious to the three short lines that signalled a two-digit answer, he asked the researcher, "Is it a positive 9?"
One student in each division believed the regrouping function offered throughout this package to be mandatory rather than optional ("in this program you have to regroup") while other students seemed unaware of the option despite its appearance on every display on which it might be used. The upper division boy who was so pleased to be subtracting decimals after all the "addings" epitomized this problem: asked why he chose to regroup while subtracting when he had ignored that option throughout his work with addition, he admitted, "I didn't know you could use it in the adding. I didn't know it said that."

Several students did, of course, use hints effectively--one noticing without being told that the letters to be selected for the "mystery words" appeared in an array at the bottom of the display and disappeared as they were chosen. Several seemed to choose to ignore hints rather than to follow them, and one boy used the hints in the pregraphing program to extend the time he could spend at the computer: consciously choosing to move in directions other than those specified by the hints, he found a hidden figure on his sixteenth and last possible try, replying after repeated probes that he hadn't used the hints "because I didn't want to."

In summary, Table 10 catalogs a variety of difficulties students in the study had in dealing with
keyboarding and speed requirements and with the hints included to help learners progress through programs smoothly and efficiently. While instructional designers can alleviate keyboarding and speed difficulties by creating programs that provide simple response options and that allow teachers to select speeds from a wide range of possibilities, dealing with the difficulties apparent in students' interactions with hints is a more difficult challenge.

Perhaps, as with the conceptual strategies discussed above, the answer lies in documentation. As far as the researcher could determine, such hints as the "short line" described above as well as a variety of others are simply never pointed out in the courseware or its accompaniments. Clearly, this is a serious omission for students who have predictable difficulties interacting with learning materials. And while the teachers were well aware of the need to remind the students repeatedly to read displays of information, teachers cannot simply be expected to notice more subtle hints that are never pointed out. Documentation, therefore, should explain the hints included in particular courseware packages and should suggest ways for teachers to explain these hints to their classes and to encourage students in their use.
Students and Reinforcement

Table 11, "Students and Reinforcement Characteristics," brings full circle this chapter's examination of students' interactions with the three areas of courseware defined in the research questions--the presentation of the stimulus, the options for and requirements of the response, and the provision of reinforcement. By displaying the problems students encountered with various kinds of reinforcement and the strategies students used in those encounters, the table completes this focus conceptually as well as logistically: many of the problems students faced in this part of their CBE experience were outgrowths of difficulties encountered with the preceding areas of courseware, and many of the strategies students used here were continuations of approaches they had found helpful earlier as well.

Throughout the table, for example, students' failure to read error messages is an extension of their failure to read hints, as described above. More significantly, students' failure to understand feedback--a pervasive problem noted in all three table segments and for all content domains--relates in large part to students' reading difficulties described throughout this document. (Students' problems with feedback are also reflected in teachers' instructional strategies described in Chapter IV.
### Table 11
**Students and Reinforcement Characteristics**

<table>
<thead>
<tr>
<th>STUDENTS CHARACTERISTIC</th>
<th>PROBLEM</th>
<th>STRATEGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Middle division</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal</td>
<td>keyboarding difficulties</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td>failure to understand</td>
<td>press return to continue</td>
</tr>
<tr>
<td></td>
<td>failure to read error messages</td>
<td>read aloud*</td>
</tr>
<tr>
<td>Numeric</td>
<td>failure to understand</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td>failure to read error messages</td>
<td>guess</td>
</tr>
<tr>
<td></td>
<td></td>
<td>let time run out</td>
</tr>
<tr>
<td></td>
<td></td>
<td>press escape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>use scrap (after error)*</td>
</tr>
<tr>
<td>Graphic</td>
<td>failure to understand</td>
<td>guess</td>
</tr>
<tr>
<td></td>
<td>failure to read error messages</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ask other student*</td>
</tr>
<tr>
<td>Problem solving</td>
<td>failure to understand</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td>Upper division</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Phase 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal</td>
<td>failure to understand</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ask other students</td>
</tr>
<tr>
<td></td>
<td></td>
<td>press escape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>choose a lower level+</td>
</tr>
<tr>
<td>Numeric</td>
<td>failure to understand</td>
<td>ask teacher or researcher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>use scrap (after error)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>guess</td>
</tr>
<tr>
<td></td>
<td></td>
<td>press escape*</td>
</tr>
<tr>
<td>Upper division</td>
<td></td>
<td></td>
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<tr>
<td>(Phase 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal</td>
<td>failure to understand</td>
<td>ask other students</td>
</tr>
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<td></td>
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</tr>
<tr>
<td>Numeric</td>
<td>failure to understand</td>
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<td></td>
<td>failure to read error messages</td>
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<td></td>
<td></td>
<td>read aloud*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>press escape*</td>
</tr>
</tbody>
</table>

*Singular instances within groups repeated in other groups.

+Singular, unrepeated instance of particular significance.
and in students' own perceptions of the effectiveness of courseware discussed earlier in this chapter.) In the area of strategies, students' overwhelmingly predominant approach to problematic feedback--asking for help--was their strategy of choice throughout their use of courseware.

**Verbal.** The particular natures of students' difficulties shed light on characteristics of courseware whose improvement could add significantly to the quality of CBE materials. Middle division students' problems with the feedback for the spelling program, for example, could be almost eliminated with a few simple improvements.

In this program, the correct spelling of the target word appears on the screen regardless of the choice a student makes. If the student's choice is correct, the word is boxed within thin lines; if incorrect, the word appears without the box. This subtle distinction is never explained, however, and almost all the students failed to notice it on their own. Similarly, although an appropriate verbal message accompanies each answer, students' failure to read these lines meant that they missed this feedback as well. Time and time again, students thought their incorrect answers were correct: "I didn't get it wrong. See? 'School'," announced one boy, referring to the screen. "That's right. 'F-R-I-E-N-D.' That's what I
pushed," argued another. In a classic illustration not only of the problems with this program but also of students' tendency to blame the computer for their mistakes, a girl explained, "I don't know what happened there, 'cause I pressed 'dog.' There it is, right there. Maybe he [the computer] just thinks I pressed the wrong one." Quite obviously, feedback that forces students to see their mistakes (in part by explaining how correct and incorrect answers are distinguished); that enables students to compare their choices with the correct ones; and that allows students to correct their own errors would be a vast improvement over the approach taken by this package.

The typing part of the reinforcement for this program also caused some difficulties, primarily those described above in connection with students' lack of typing skills and keyboard knowledge. Even the good spellers disliked the program's heavy typing requirement ("This is ridiculous. This is taking forever. . . . I'll be 80") and the program's unusual response acceptance formula exacerbated the students' problems. This formula accepts as correct any mistypings corrected before words have been completely typed but labels incorrect words that have been finished--but not yet entered--and then corrected. "I just hate that," complained one girl vehemently. Others dealt with their frustration with the typing in various ways--
such as ignoring the error messages and banging the return key repeatedly in unsuccessful efforts to make the program move ahead without the typing. Several students simply seemed defeated by the typing. One boy, for example, typed "Christn," concluded he was not going to get "Christmas" correct, sighed, and pressed return to give himself another chance. Another boy—generally the quietest one in the class—summarized the group's assessment of the difficulties with feedback and reinforcement encountered throughout the program: "You don’t know if it’s right and you do it over and over and over again," he said disgustedly. "I hate that."

Upper division students, who used different kinds of verbal programs, encountered other problems and developed other strategies. Phase 2 students, for example, worked in teams on the gamelike spelling program described above and collaborated with each other on both initial and corrected responses. Even with collaboration, several pairs of Phase 2 students, as described earlier, failed to understand the task involved in a program about political candidates and were unable to use the feedback to correct their misunderstanding.

Phase 1 students, who used several programs requiring rather extensive reading, frequently relied on others' kibbitzing to understand their errors and to correct them.
Several students in this group—whose difficulties understanding feedback echoed their difficulties understanding content in general—simply gave up when they could not complete a particular program successfully. One boy, after attempting several rounds, announced, "That's enough for me" and joined another group. Another boy, having had similar difficulties in several attempts, said, "I got it all wrong. [Pause] I don't want to do this any more." A third boy—who, unlike the others, had ventured into a more advanced segment of the program—chose to branch himself to a lower level after he had been unsuccessful on his first round. In all three cases, students' problems stemmed as much from the courseware as from the children's language difficulties: the program accepted a selection of three-word "free" responses but required these to be in a specific format. Because the program never explained why students' alternative choices or wordings were incorrect, the students had no possible way of correcting their errors and no recourse except to assume that they had failed and that they would continue to do so.

Suggestions for improving the stimulus and response characteristics of verbal courseware—such as, using speech synthesis and simple language and requiring appropriate responses in order for the program to
proceed—can obviously be applied to the reinforcement domain as well. More specifically, however, feedback should include explanations of students' errors and suggestions for responding correctly in subsequent attempts. Without an understanding of what they did wrong, students cannot learn how to correct their mistakes. Courseware that fails to provide adequate feedback thus robs students of opportunities for many successful learning experiences.

Numeric. A number of students claimed that the feedback provided by the math program used most extensively during the fieldwork was sufficient to allow them to correct their own mistakes, and observations tended to corroborate this assessment. Indeed, in many ways this is an excellently designed program; the problems cited below were among the very few that surfaced after close and prolonged observation. Nevertheless, in this program as well as other math packages, students did fail to understand or respond appropriately to feedback and used a number of strategies to overcome their difficulties.

One source of these difficulties was students' persistent failure to read error messages, particularly in the most widely used program. Here, if a student made a certain number of errors (determined automatically according to the complexity of the response required) the
program would issue an instruction to press the return key successively to make each step of the problem's solution appear on the screen. A number of students in both divisions seemed not to notice this instruction and tried instead to correct the problems by entering numbers. Typically, students attributed the program's failure to move ahead to the computer's error rather than to their own—"Something's wrong with the computer"—and required adult assistance to continue.

Typically, too, students were unreceptive to having the computer correct their mistakes for them: one upper division boy greeted the screen's "Let-me-help-you" prompt with a strenuous, "I don't want you to help me, computer"; a classmate's "No! No! No! I don't want to be helped" echoed this reaction. "OK, but how do you help me, you stupid computer?" demanded a middle division girl. "Yeah . . . yeah . . . yeah. OK . . . OK . . . OK," urged another impatiently as the program worked through the steps of the problem she had missed.

Indeed, it was primarily in reference to this program that both students and teachers expressed a desire for courseware that allowed them to work through the processes of solving problems and correcting errors directly on the screen. In spite of the program's step-by-step error correction, a number of students felt the feedback was
insufficient: it told them only that they were wrong and not why they were wrong and simply displayed steps rather than attacking the underlying causes of students' errors. A program that would suggest possible causes and give students opportunities to consider these suggestions and to correct their answers on the basis of this consideration would be an improvement in the minds of many of the participants in this study.

This program caused other difficulties for students as well, particularly in its use of a large red "X" to signal the beginning of the feedback segment described above. Although one student insisted he liked the "X"—adjusting the dials on the monitor to find the most pleasing contrast—and several expressed positive or neutral sentiments about it, most of the students who spoke about this signal complained: "I feel like getting a sledgehammer and hitting it," responded one middle division boy; said another, "You practically go flying to Mars." Several older students articulated the embarrassment they felt when the "X" appeared: "It makes me embarrassed 'cause, like if it's an easy problem and I [just] hit a wrong key, and . . . people in the classroom . . . look over and see. . . . They just think, oh, like I don't know nothing." Several students matter-of-factly ascribed all such errors to the computer—implying a lack of just cause
for their own subjection to embarrassment—and a number concluded that the "X" would not be a problem if others couldn't see it. During the observations, students generally pressed return as fast as they could to remove the "X" from the view of the researcher and their peers; only rarely did students use the device as a signal to study the errors they had made. "Sometimes I just press in any number and just get it over with," explained one boy. "Get them all wrong 'cause I just don't like it. But I don't think that ['X'] helps."

One final difficulty with this program occurred in both divisions when the reinforcement for problems appeared before students realized they had finished entering their answers. In all cases, this situation involved problems in which the final digit to be entered for an answer was zero. Since the program requires right-to-left entry, adding this final zero to a problem is unnecessary; thus, the program considers the answer complete upon the entry of the preceding digit. But the appearances of animated characters upon entry of what students considered the next-to-last digit unnerved a number of them. "Why'd it do this? I ain't done the problem," asked one startled upper division girl; when the same thing happened a few minutes later, she frowned at the computer "'cause that came on." A middle division girl confronted with the same situation
reacted even more strongly: "Hey! I'm not even finished yet! They didn't even let me finish the problem, those cheapskates!" For a later occurrence, one that surprised her only momentarily, she adopted a pouting expression and volunteered, "Still ... cheapskate game."

Several other students complained about this program's immediate reinforcement, even in situations in which the problem was not so apparent. Upset by the fact that the program accepts and judges responses before students are ready to commit to them, these students wanted a chance to confirm their answers after typing and before entering them. One girl suggested a solution that would alleviate both kinds of problems students experienced with the program's single-stroke acceptance of responses:

You know what would be neat? If you could ... finish your problem. ... And then ... it should say at the bottom, "Do you think this problem's right or wrong?" And you look at it again. ... And so if it was right, you would say "Yes" and then it would tell you if you were right or wrong. If you said "No," it would give you another chance to do it over.

Students used several familiar strategies in coping with this and other math courseware: asking for help, guessing, resorting to scrap paper after making errors. Several, as described in an earlier segment of this chapter, used their responses and the feedback for them to learn what was expected of them and to proceed through
subsequent tasks effectively. One student read feedback aloud (as did another for feedback in the verbal domain) and several, working in a timed program, simply let time run out when they did not know the answers.

Several students in each division also found an effective way of dealing with errors in order to maintain the high scores they found so rewarding: they pressed "escape" to begin again, thus resetting the program's counter so that it would not reflect earlier mistakes. One upper division boy explained the rationale this way: "I could go back and start over 'cause my average is only 80%. I could go back and do the problems over. But I won't 'cause you're looking." The "resetting" strategy was particularly attractive to middle division students, whose teacher had pointed it out to them "because in the basic functioning things that I was having them do, I wanted them to feel real successful. And if they missed one, I wanted them to go back and do it over again." Far from being concerned about this approach, this teacher saw it as a real advantage: "I'm just content that they were practicing that hard to get 100%. They were really getting those [math] facts over and over again."

In spite of the general effectiveness of numeric feedback, particularly that provided by the package used most extensively during this study, designers can find ways
to improve this dimension of courseware as well. As with verbal feedback, explanations for errors should be provided and programs should correct students' errors only when students themselves have concluded that they are unable to make such corrections and have selected an error-correction option. In addition, math programs—like others—should avoid mechanisms that attract attention to students' errors and should include mechanisms that allow students to evaluate and commit to their answers before receiving feedback and reinforcement of any kind.

**Graphic.** Verbal feedback accompanied visual displays in the graphics based programs used by middle division students, and so many of the problems students evidenced here (e.g., failure to read error messages) were similar to those described above. In addition, however, students generally seemed unable to determine what was wrong with their visual creations, even when these were supposed to match or differ from sample figures on the displays: "I don't know what I'm doing wrong with this one," moaned one girl as she tried to build the third in a series of figures that were to differ in one way; "I'm getting it right! I'm getting it," announced a boy as, for the second time in a row, he built a figure that differed from the sample he was supposed to match. In another program, a student who had entered the wrong coordinates in his drawing of a figure
failed to see that the point that appeared on the screen was extraneous to the pattern.

The reasons for students' problems were difficult to discern. In part, it seemed, they stemmed from students' failures to understand the task; in part, from their forgetting that task and getting lost amid the various factors they were trying to manipulate. In any case, since students profited neither from the error messages nor from the visual components of reinforcement, they were left with very few strategies—guessing and asking for help. While it is not clear what instructional design can do to remedy this situation, several options might be explored. For example, visually highlighting discrepancies between target figures and students' input—perhaps through inverse video or small flashing arrows—might enable students to see and correct their own mistakes.

Problem solving. Students who used several of the problem-solving programs also failed to understand either visual or verbal feedback, and the reasons for this are equally difficult to discern. The following exchange indicates the severity of the problem and, consequently, the difficulty in arriving at solutions:

Student: I'm gonna ruin it. [Pause] I think I understand now. [Pause] Yep, I ruined it.
Researcher: Why did you ruin it?
S: Well, I was confused in the beginning. [Pause] I'm just guessing. [Pause] I'll find out in a few minutes. [Pause] Yep, I knew it.

R (after he had made some changes in his solution): Why did you do that?
S: Because they told me it was not done properly.
R: Do you know why "it was not done properly"?
S: Not really.

The inherent complexity of problem solving as a learning task makes it extremely difficult to design effective courseware in this domain. Moreover, the researcher's uncertainties about what caused students' errors coupled with students' own inabilities to understand and articulate the problems they experienced with problem-solving packages create significant obstacles to offering ideas for improving the feedback for this kind of courseware. Beyond the logical extensions of suggestions for bettering verbal and visual feedback described throughout earlier sections of this report, instructional design techniques for enhancing the effectiveness of feedback in this domain remain a mystery.

In summary, Table 11 reveals that students routinely failed to understand feedback and failed to read the error messages that would have led them to that feedback. More significantly, however, students were plagued by feedback that does not adequately distinguish correct and incorrect answers, that fails to reinforce correct responses or that
reinforces them prematurely, that does not explain the reasons for errors, that embarrasses students, and that is in many ways inaccessible to them. In fact, the number and pervasiveness of students' difficulties with feedback suggest that it is in the reinforcement stage that the effectiveness of courseware for students like those at Marburn breaks down most seriously.

Perhaps an even greater problem, however, exists beyond the difficulties displayed in the table and discussed above: because only those packages that actually provide feedback were candidates for inclusion in these forums, several programs could not be presented because they simply do not provide any feedback at all. While an absence of feedback may be acceptable and even preferable in timed programs designed to drill on the association learning of basic facts, such absence is a serious problem in courseware that purports to teach new skills—such as the graphics based problem-solving program critiqued in detail in the previous segment of this report. It was these programs as well as those with inadequate feedback that required the extensive teacher intervention described in Chapter IV. Obviously, such programs seriously limit the potential of CBE for fostering independent learning.

The implications for instructional design are clear. First, in most cases feedback should be included. And
second, feedback should meet a variety of criteria in order to be maximally useful to students, particularly those with learning problems: it should be accurate, unambiguous, understandable, explanatory, timely, and nonembarrassing. In addition, feedback should conform to the attributes suggested for other segments of the instructional sequence described in this report. Similarly, documentation should explain the precise nature of the feedback used in any program and should provide clear suggestions for teachers to use in helping students profit from it.

Students' Perceptions of Reinforcement

Table 12, "Students' Perceptions of Reinforcement," displays in hierarchical fashion those courseware devices students found to be effective and ineffective reinforcers. Not surprisingly, intrinsic reinforcement— as indicated by such extrinsic signs as high scores and progression to higher levels of difficulty— was the most popular device across all three segments of the study.

Students' attempts to make courseware motivating by introducing or augmenting competition, as discussed earlier in this report, suggest one aspect of the significance of achievement as a reinforcer: "Hey! I beat my other score"; "Has anybody else gotten that high?" Students' willingness to do assignments several times to get 100%
<table>
<thead>
<tr>
<th>STUDENTS</th>
<th>EFFECTIVE</th>
<th>INEFFECTIVE</th>
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<tr>
<td>Middle division</td>
<td>signs of achievement</td>
<td>graphics</td>
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</tr>
<tr>
<td>(Phase 2)</td>
<td>graphics</td>
<td></td>
</tr>
</tbody>
</table>

*Singular instances within groups repeated in other groups.
+Singular, unrepeated instance of particular significance.
suggests another: "They wanted 100% on their charts," said Teacher B. "They didn't want anything but 100%--which is kind of funny when you figure that they didn't come from a background of getting all As. But they want that so desperately this year."

Examples of students' pursuing and glorying in their successes fill both the fieldnotes and the interview transcripts for this study and provide further evidence of the importance of achievement as a reinforcer. Some selected, scattered instances will illustrate this point. Several students, for example, raised their hands above their heads in the traditional boxer's victory signal when they did especially well; one girl spread her arms and bowed like an actress accepting applause when her answers were correct. Students would ask to continue beyond their assigned times when they saw how well they were doing or would slip in extra tasks when they were having successful CBE experiences. Students announced high scores to the class ("Ninety-one hits, people!") and one complained about a program that did not keep score: "Well, did I get 100%? I don't know. It doesn't tell me." A number of students tried to get through as many problems as they could without making mistakes ("that's the only really way to make it fun").
In the interviews, when asked to specify which of several reinforcers they preferred, students overwhelmingly mentioned getting high scores and going up levels as superior to other forms of reinforcement. Although several dissenters liked advancing only "a little" or not at all ("because as you go up the much harder it is") most students clearly thought achievement and the acknowledgement of it are the best reward. One middle division boy, during an observation session, volunteered this explanation of what seems to be the majority opinion: "When you do the problems, them things show up, like the [animated graphic]. And not just that. I like doing the problems and seeing if I get 'em right. I think I got 100%.

Although graphics seemed less significant than achievement as a reinforcer, almost all the students said they liked the pictures, color, and movement in the courseware they used. Students generally responded positively to graphics as well—particularly to highly animated ones: "That thing winked at me!" Some students, especially the younger or less able ones, were utterly enthralled by the animated figures that greeted their successful completion of math problems: "Oh! I like that. I like that one best. [Pause] Oh! . . . I like that one. [Pause] Oh! . . . I like that one, too." Even the older
students, in spite of their typically adolescent need to be "cool," revealed a liking for the graphics: both Phase 2 math classes who used the same program protested when Teacher A offered to eliminate the graphic component of the reinforcement. Students' ironic comments (including "Golly gee" and "Isn't that cute?") only partially masked their pseudomaturity: the comments were made only when students were sure the graphics would remain.

Several students in both divisions complained about specific graphics, about color quality, or about designs that seemed to be aimed at younger children—a pervasive problem in many materials used by handicapped students. Only one girl expressed any strong negative opinion about graphics in general: "They're a distraction because I have my train of thought. Frankly, I don't like pictures popping out of the screen."

Students responded differentially—and even, in many cases, stereotypically—to individual graphics: one day a middle division girl screwed up her face and announced, "Yuck! A worm coming out of an apple"; several upper division boys commented favorably on an exploding stick of dynamite, and one started making noises like an explosion before he even got into the program he knew contained it. For the most part, however, students simply seemed to enjoy whatever graphics were presented and to notice the absence
of graphics in programs that did not include them: one student, asked what would make a particular program better, replied, "Put a design if you make it right. Something like that."

While students seemed to like the graphics, the figures seemed to lose much of their power to captivate after their first few appearances. "I know all these pictures now," announced an upper division boy after he had done about a dozen problems; "They only give you [a few] characters," complained the middle division girl who professed not to like graphics; "I wish they gave you more." Once students outgrew their fascination with the pictures, however, many seemed to find another use for them. For these students the figures became markers—signposts that students looked for as evidence that answers had been correct. Thus, although the graphics did not endure as reinforcing in themselves, they continued to be effective as signs of the achievement that was the most powerful reinforcer.

Verbal praise seemed to be the least effective of the reinforcement devices included in the courseware used during the fieldwork. While several students read the "supers" and "greats" aloud, only one seemed to pay close attention to them—raising his eyes from the keyboard to read them as they appeared. Even he, however, was not
terribly impressed: "That's all it says is 'Wow'?"

A number of students volunteered complaints about verbal reinforcement: "They need some new words here, man," suggested one upper division boy. "This is only the first one and it says 'Super' already. Really!" sneered an upper division girl. "Don't you 'That's better' me," chided a middle division boy. Few students seemed to attend actively to verbal praise, and several dismissed it altogether—"'cause those things are dumb, those 'wows.'" Although "those things" seemed to serve many students as markers, as the graphics did, they seemed minimally attractive and effective across all three segments of study participants.

In summary, Table 12 suggests that both signs of achievement and animated graphics were perceived positively by students in the study and were therefore reinforcing. Verbal praise, which many students tended to ignore, seemed considerably less effective. Because there were both positive and negative reactions to all three reinforcement options, however, courseware should allow teachers to select whatever option or combination of options is perceived as most appropriate for the tastes, ages, and needs of individual students.

Instructional designers should be aware that achievement is the most effective of the reinforcers
displayed in the table and that providing frequent opportunities for seeing success—for example, allowing students to earn 100% after only seven or eight problems—is desirable. Perhaps the most interesting finding related to the tables is the discovery that graphics, even rather sophisticated ones, are less reinforcing in themselves than many packages' emphasis on them would seem to suggest: although animated graphics are attractive and motivating initially, they quickly lose their power and become markers—signs that many students expect to see but seldom seem to consider consciously. Instructional designers should consider this, too, and focus their attention on providing reinforcement that is truly rewarding rather than momentarily arresting.

Conclusions and Implications

As was the case in Chapter IV, the major conclusions and implications of this chapter are presented and discussed within the appropriate subsections above. Because Chapter V covers such a wide array of topics, implications of those conclusions for instructional design are also discussed within each subsection as appropriate rather than reserved for this final segment of the chapter. The purposes of the following discussion, then, are to highlight conclusions and implications that span the
individual topic areas covered in the chapter, to relate these to the research questions, and to cite some of their additional implications for instructional design. It is important to note, however, that an awareness of the specific findings in which these general statements are grounded is critical to a full appreciation of this section of the report.

The nature of the courseware used during the fieldwork precluded an investigation of several of the instructional dimensions outlined in the research questions—for example, elements of concept development and the provision of various levels of questioning. Nevertheless, a number of broad conclusions can be drawn about students' interactions with characteristics of courseware across the three segments of the instructional sequence—stimulus, response, and reinforcement—delineated at the outset of the study. Marburn students' pervasive reading difficulties, for example, affected these interactions from students' initial encounters with courseware procedures throughout their work at the computer.

While simpler, more direct language would alleviate some of students' reading difficulties, in many cases the problems are too severe to be overcome through this approach alone. Thus, instructional designers should consider ways to present and ask for information in
nonverbal or highly structured verbal ways—through simple charts and diagrams, for example, or through progressive revelation that requires a particular response before the program proceeds to the next step. Most especially, speech synthesis should be employed in courseware for students like those at Marburn, either to augment written presentations or to substitute for them. Indeed, students' frequent attempts to augment visual/verbal material through the senses of hearing and touch suggest that options for a variety of input and output modes should be available in courseware. Again, the final decisions about how and when to use such options should be left to the individual teacher; the designer should provide flexible, easily selected options from which the teacher can choose.

Students' attentiveness to sound suggests that courseware for LD students should make better use of the sense of hearing. Not only should speech synthesis be offered, as described above, but tones could be incorporated to focus students' attention on relevant stimulus characteristics and to cue students about response requirements as well as to signal correct and incorrect answers. In addition, music could be used both as an integral part of lessons and as a reward for student achievement. Similarly, graphics could be combined with sound to increase students' chances of attending to and
understanding elements of the stimulus and feedback for incorrect responses. Clearly, for students for whom the visual/verbal channel is often the weakest, mechanisms for bringing other senses into students' interactions throughout the instructional sequence should be more thoroughly explored.

Motivational features were lacking in much of the courseware used during the fieldwork, and students' boredom often led them to inject competition with themselves and others into their CBE experiences in order to make these more interesting. Throughout their encounters with the three segments of the instructional sequence, in fact, students gave ample evidence of the power of competition as a motivator and reinforcer. Although the issue of competition among students is a sensitive one, designers must at least acknowledge the existence of this pervasive phenomenon. Once accepted for the commonplace occurrence that it is, students' attraction to competition can be used in positive, constructive ways designed both to enhance self-concepts and to provide the fun students expect when they sit down at a computer either at home or in school. More importantly, this attraction can be used to help and encourage students to learn the wide variety of concepts and skills available to them through CBE.
While competition can thus be used productively in courseware, designers should be aware that it can also be counterproductive. Students' tendency to turn unfathomable programs into games, for example, is an understandable approach but one that seriously interferes with learning. Obviously, designers should take several steps to limit the need for and the possibilities of such a strategy. Clearly stated goals that enable students to grasp the purposes of their work are one method for avoiding this approach; mechanisms for ensuring that programs do not move on unless responses are consistent with those goals are another.

While clearer goals, more accessible language, sound and graphic enhancement, and better motivational devices would enhance the quality of courseware across the three segments of the instructional sequence, a number of techniques could be used specifically to improve courseware's techniques for eliciting responses. Simpler keyboarding tasks, adjustable speed requirements, and the opportunity to perform all operations within a program, for example, would all be improvements in this dimension.

Most importantly, however, the inclusion of hints and the provision of information about what these are and how to use them would significantly enhance students' abilities to respond correctly in all content domains. In particular, students need to be made aware of how to
interact with courseware effectively with minimal teacher intervention. Students’ reliance on teacher and researcher assistance—their chief strategy throughout the fieldwork for this study—seriously attenuates the power of CBE to foster self-reliance and to provide an independent learning experience for students. Clearly, for LD students as well as for students without learning problems, designers should create courseware and documentation that offers guidelines for independent learning rather than leaving this important achievement to chance.

The need for such learning guidance extends to the feedback and reinforcement component of courseware as well. Indeed, it was in this final segment of the instructional sequence that students seemed to have the most serious difficulties interacting with CBE materials. Throughout the fieldwork, students were frequently brought to a halt by displays that told them they had made mistakes but gave them no clues about how to proceed. Both students and teachers complained about the lack of explanatory feedback in courseware, and indeed it seems to be one of the most serious difficulties discovered in this study. Observations, interviews, and document analysis all make it very clear that feedback in courseware must always include reasons for errors and should provide mechanisms by which students can correct their own mistakes.
Not surprisingly, the successful completion of program tasks was the most powerful reinforcement students obtained from courseware. Although animated graphics and verbal praise were useful as signs marking such achievement, neither was as significant as success in holding students' interest and encouraging them to continue working to solve a few more problems or spell a few more words. Programs that allowed students to experience success—like getting 100%—after relatively few tasks were especially effective. The creation of courseware that frequently confirms students' perceptions of themselves as successful would undoubtedly enhance their feelings of independence, self-confidence, and active agency as well.

Students developed a number of academic and coping strategies for interacting with courseware, some of which were more successful and appropriate than others. As suggested above, students' predominant strategy of asking for help generally proved effective; students' strategies for dealing independently with courseware, however, ranged across a continuum of effectiveness from generally successful (for mathematics) to almost nonexistent (for problem-solving). Unfortunately, students did not in fact seem to have many sophisticated strategies for responding to courseware. Designers should thus take care to incorporate suggestions for appropriate approaches into
documentation and perhaps into courseware itself. As with instruction in the effective uses of hints, explanations of the appropriate uses of strategies would enable students to achieve both greater independence and increased success with CBE.

Unfortunately, observations of students' interactions with courseware throughout this study did not yield much evidence of the medium's enhancement of students' independence or of its contributions to students' development of other personal and higher-level academic skills. Although both students' perceptions and the researcher's observations led to the conclusion that CBE did in fact foster students' mastery of a number of basic academic skills, the same could not be said for the more abstract achievements—such as improved memory, problem solving, divergent thinking, and error handling—outlined in the research questions.

In part, of course, this situation can be attributed to the nature of the courseware used most extensively during the fieldwork; serious flaws even in the more sophisticated packages that were used, however, must also be cited as factors limiting the effectiveness of CBE in this regard. In any case, although praise for personal and higher-level skill development is scattered liberally throughout the literature about CBE for students with mild
learning handicaps, the findings of the study reported here do not confirm those contentions. On the contrary, these findings yield no evidence of such achievement and suggest instead that both improvements in courseware and close attention to helping students use that courseware more effectively are necessary to make CBE successful with LD students in sophisticated areas.
CHAPTER VI
CONCLUSIONS AND IMPLICATIONS

The focus of the study reported in this document was a broad one—the interactions of over 60 learning disabled (LD) students and 7 of their teachers with the instructional dimensions inherent in 26 commercial microcomputer courseware packages. Because it investigated so many individuals' perceptions and daily uses of such a wide variety of specific attributes, the research yielded findings that are too numerous and varied to be summarized adequately in one final chapter. Thus, the bulk of the conclusions and implications about participants' interactions with courseware are reported throughout Chapters IV and V; the concluding section of each of those chapters draws general inferences from specific findings and relates these to the particular research questions addressed through the chapter.

The purposes of this chapter, then, are to highlight some overall conclusions, to place them in a broader context, and to discuss the implications of the study for future efforts both by instructional designers and by researchers in this field. The chapter is divided into two
segments— one for issues related to instructional design and one for methodological concerns.

Issues Related to Instructional Design

The research questions that guided the study divided the investigation into two major sections: (a) teachers' perceptions and uses of various instructional dimensions of computer based education (CBE) and (b) students' perceptions of and interactions with these dimensions. The following segments of this chapter also deal separately with information provided by each kind of study participant and introduce themes and findings that in some ways go beyond the issues encompassed by the original research questions.

Teachers' Perceptions and Uses

Two predominant themes emerged through the comments and behaviors of the teachers who participated in the study: process and flexibility. To be optimally useful to teachers of LD students, courseware should both incorporate a focus on the processes underlying target concepts and be flexible enough to allow the teacher to present both concepts and processes in a variety of ways keyed to the needs of individual students.
Teachers' focus on process is not surprising, since deficient processing ability is characteristic of the LD child. What is surprising, however, is that very little courseware exists to address this topic. Again and again, teachers had to augment feedback that merely pointed out student errors without explaining why answers were wrong or how correct responses might be obtained. Indeed, although feedback was adequate when students fully understood the concepts at hand and made such "clerical" errors as forgetting to insert a decimal point, it was never sufficient when students made more substantive errors and were unaware of the reasons for their mistakes and—in some cases—unaware that they had made errors at all. Teacher A explained the problem this way: "Sometimes they can see they've made a mistake. You can show them the answer—fine—but they have no idea where it came from."

Thus teachers want courseware that demonstrates processes, leads students through them, remediates errors in processing, and even drills on process. Instructional designers would do well to focus on this issue, in particular providing mechanisms that would allow students to work through processes on the screen and see the results of each of the steps they take.

Teachers' needs for flexible courseware seem to stem from their responsibility for orchestrating the learning of
students with a variety of needs. Because LD students are notoriously variable in their abilities and performances, both within the group and as individual students from day to day, it is particularly difficult for a teacher or designer working with this population to specify once and for all what will be most effective for a particular student. Thus, teachers need courseware that allows them to specify content, determine pace, involve several senses in responses, provide record-keeping and "save" routines, and so on. Teacher G—an exploratory user/novice—described a word-match program that was especially useful because of its flexibility:

I liked it because it was open ended. . . . So I could put them on there for spelling and say, "Use your [own] spelling words . . . and give a definition for the word and use it that way." Or for the [lower-level students] "Just put your spelling words in the blocks" and that would give them help with spelling out the words. . . . when we did mythology . . . they had to [spell the names of] gods and goddesses . . . and that was just great fun. So that's why I like it. You can plug things into it and be creative with it.

Instructional designers for this group, then, should create courseware of maximum flexibility and with relatively simple procedures for inserting content and adjusting performance options and requirements.
Students' Perceptions and Interactions

Marburn students' sophistication about computers and CBE suggests that courseware for such students must go beyond the familiar packages most frequently found in schools today. Since, in a number of cases—particularly with the older children—students' computer skills and awareness seemed to outpace their mastery of basic academic facts, the challenge for instructional design seems to be the creation of courseware that strikes the appropriate balance between a basic level of content and an advanced presentation format. Although well-designed, appropriate packages that are sophisticated in both content and format could certainly be valuable for this group, it is important to remember that basic drill and practice programs presented in creative ways can perhaps be more useful for such students.

Participating students shared their teachers' wishes for courseware that would help them with processes—and particularly for packages that would explain the reasons underlying errors and that would allow students to correct their own mistakes based upon these reasons. This need for explanatory feedback is one of the primary themes that emerged from the study, and its importance is related to another primary theme—the need for courseware to include more mechanisms for fostering student independence.
Students' heavy reliance on adult assistance throughout their interactions with courseware provides extensive evidence that students were simply not able to complete courseware packages independently. The provision of explanatory feedback would greatly enhance students' abilities to use courseware on their own and to grow in self-confidence and self-concept as well. Without adequate feedback, students have no recourse but to rely on the intervention of their teachers each time they make a substantive mistake. When this intervention is as extensive as it was during this study, the lack of student independence becomes a serious question.

The most frequently heard suggestion for enabling students to progress more independently through courseware involved the provision of all elements--directions, content, response options, feedback, and reinforcement--through speech synthesis. "I want talking. I have kids who can't read. I need programs to talk to kids," lamented the headmaster in a statement that summarizes much of what both teachers and students had to say on this issue. Various specific recommendations for providing speech--speech synthesis, tapes of programs, headphones that would prevent the sound from distracting others--were suggested by students during the interviews. Creating materials that reinforce or replace printed presentations with spoken ones
should clearly be an important priority for those designing courseware for students who have such profound reading difficulties as those documented in this report.

Students must be able to progress through courseware instructionally as well as independently. Although theorists in the field of CBE for LD students decry courseware that traps students in routines they cannot escape, the observations in this study suggest that quite a different situation exists. Time and time again, students were able to complete individual program tasks without understanding either the purposes of the programs or the quality of their own interactions with them. Programs permitted students to do one mathematical operation when they were supposed to be learning another, to be highly successful at answering questions without reading the text on which the questions were based, and to perform individual problem-solving tasks without even considering the rules those tasks were intended to illustrate. Perhaps even more troubling, students were often unaware of this problem in courseware and were therefore unable to monitor their learning or adequately judge their success: "It's teaching me something. I know that. I can't think. I don't know. I know it's teaching me something or [the teacher] wouldn't have me working on these things," said a middle division boy who had completely ignored the problem-
solving aspects of one program and turned it into a game.

Some of the problems related to this issue are, quite obviously, beyond the control of instructional designers: students will always guess at answers and children will always create unanticipated ways to avoid tasks they find unpleasant. Still, a number of problems could at least be alleviated by tighter, more careful instructional design. In particular, courseware should be designed to force students to perform relevant operations before moving on and to inform students clearly about their success or failure at each step.

Courseware should also include hints that would assist students in performing successfully, and either the courseware or its documentation should include explanations of these hints and of how to use them effectively. Throughout the fieldwork, students usually seemed oblivious to hints—unaware of these clues that could be particularly helpful to students with learning problems. Similarly, students developed few sophisticated strategies for performing tasks or attacking concepts that were difficult or unfamiliar. Because instruction in the use of hints and strategies would greatly enhance students' opportunities for independence and success with CBE, this instruction should be a primary emphasis in CBE, particularly in courseware documentation.
One widespread student strategy--making games out of courseware they did not understand--suggests both that students expect courseware to be gamelike and that the competition inherent in games is very attractive to students. Indeed, any number of the researcher's observations and the students' comments revealed the extraordinary power of competition as a motivating factor. One reading comprehension game, for example, kept five middle division students reading for almost an hour--including, at the students' request, through recess. Not only did students respond with enthusiasm to courseware designed to be competitive, they also introduced competition into packages in which there was no evidence of a competitive thrust. Throughout the fieldwork, students actually used the words "disk" and "game" interchangeably and spoke of "playing disks" both at home and at school.

At the very least, students seemed to expect courseware to be as interesting as the games they used at home. Students' universal response to an interview question about how to make courseware better was to provide more game formats. While an adult might at first view this as a frivolous suggestion, further consideration reveals it to be an important one. These children of the electronic age know how exciting computer use can be; they are not intrigued by dull, plodding, workbooklike programs. If
instructional designers are to capitalize on students' strong interest in the computer, they must follow students' recommendations to "make it funner" by creating programs that are more visually interesting, more challenging, and more rewarding.

Designers must also be careful, however, not to sacrifice substance for purely extrinsic factors. Throughout the fieldwork, it was clear that "wows" and "supers" and animated graphics were useful primarily as markers rather than as rewards and that achievement was a far more powerful motivator than any extraneous device; even high scores were valued for what they signified rather than in themselves. Students were in agreement that doing well is the best reinforcement: "Accomplishing something's better than the pictures," declared a middle division boy—in a tone that indicated surprise that the researcher had even asked.

In terms of the instructional design of courseware for LD students, the obvious next step resulting from this study is to weave the themes presented in this chapter as well as the specific and general findings delineated in Chapters IV and V into a comprehensive set of criteria to guide such design. These criteria would, of course, be strengthened by the insights gleaned from additional studies of this population. Virtually every area suggested
in the research questions in Chapter I could be examined more closely—particularly those, like concept development, that could not be adequately addressed in this study because of the kind of courseware currently on the market and therefore in predominant use at the research site. In addition, further examinations of the academic and coping strategies students use in dealing with courseware could yield especially significant information about the interaction at the center of the learning process. A deeper understanding of the ways students confront and cope with materials designed for them could certainly lead to improved design of those materials.

Issues Related to Methodology

Although quantitative studies designed to measure the impact of specific instructional dimensions can certainly add to designers' and researchers' expertise in the emerging field of courseware for students with mild learning handicaps, the deepest insights into the intricacies of students' and teachers' interactions with those dimensions will come only from additional naturalistic examinations of courseware that is actually used in a variety of special education settings. The likelihood of such studies being conducted, however, is attenuated by a number of factors—including the labor
intensiveness of this kind of research. If such studies are to occur in sufficient numbers to lead to findings that are relevant to a large number of designers and users, a way must be found to diminish the clerical aspects of data collection, analysis, and presentation.

Current computer technology is adequate to the task, although no validated packages analogous to SAS and SPSS—so widely used in quantitative research—exist to streamline the qualitative researcher's efforts. Therefore, a critically important area for future research involves the creation and testing of utility packages that can sort data in various ways, generate meta-matrices automatically, and subsequently convert those meta-matrices into condensed chart form. While no package could—or should--free the researcher from such intellectual tasks as identifying and refining general and specific research and interview questions, arriving at preliminary interpretations, developing coding categories, and drawing final conclusions from the coded materials, packages that would facilitate the efficient accomplishment of the clerical aspects of these tasks would be tremendously useful.

In particular, packages that would allow researchers to sort data in a variety of ways (e.g., by coding categories, by cross-referenced coding categories, by
subcategories, and by participants) and to manipulate the sorted materials according to emerging insights (e.g., by allowing the merger of files related to particular patterns and themes) would not only substantially reduce the time currently devoted to accomplishing such tasks by hand but would also increase the number of ways the researcher could look at the data and therefore significantly increase the possibility of arriving at more—and more insightful—conclusions. A next step in improving the quality of qualitative research, then, involves exploring and developing technological workhorses at least as sturdy and sophisticated as those currently used in the quantitative domain.

Summary

In summary, it is important to reiterate that the majority of teachers' and students' interactions with the courseware in use at Marburn during the fieldwork were successful. Although the purpose of this report is to identify problems with these interactions that might be alleviated through better instructional design, this emphasis on problems should not eclipse the fact that, in general, students and teachers used courseware quite well. Elimination or alleviation of the problems described throughout the three concluding chapters of this document,
then, would enhance teaching and learning experiences that are, for the most part, already quite profitable.

Nevertheless, a number of improvements in commercial courseware can certainly be made; observations of and interviews with both teachers and students revealed a variety of measures on a continuum of complexity that could be taken to strengthen the materials that were used during the fieldwork. The simplest and most direct of those measures are detailed throughout Chapters IV and V; those chapters also contain more global suggestions based upon the specific findings reported in the chapters. Included in this final chapter are a number of further extensions of those specific findings and some general suggestions derived from the specific findings that should be considered in the design of CBE materials for LD students.

There is more to be done—more studies to be conducted, more findings to be discovered, more distillations of findings into comprehensive guidelines for the design of courseware for LD learners. The insights described throughout this report are viewed as early steps into a frontier that has only recently been opened. As extensive and well grounded as the findings of this study are, they represent only some of the detailed information that will be necessary to create courseware that is truly useful for LD students and their teachers.
APPENDIX A
MATERIALS RELATED TO CONSENT
Dear Parent/Guardian:

With your permission, I would like to include your child as a subject in a study of the ways in which learning-disabled students and their teachers perceive, react to, and interact with various instructional dimensions of microcomputer courseware. I am undertaking this study in partial fulfillment of the requirements for my PhD in Computer Applications in Education and Training from The Ohio State University. My advisor at Ohio State, Dr. Keith A. Hall, is the principal investigator who is directing this dissertation research.

As you no doubt know, the microcomputer has fired the imaginations of many concerned with uncovering ways to tap and maximize the potentials of the almost 2 million school-age Americans identified as learning disabled. As promising as this tool is, however, little systematic and rigorous research has been undertaken to document and evaluate specific factors in educational software that enhance the learning of such students. And that is the purpose of my research—to examine the ways in which learning-disabled students and their teachers respond to a number of instructional dimensions thought to be critical in computer courseware: the design of screen displays, the kinds of questions students are asked, the kinds of feedback presented after responses, and so on. As an instructional designer, I am interested ultimately in learning how learning-disabled students interact with each of these dimensions so that future courseware can be designed to incorporate them more effectively.

Because I will be looking for ways to improve courseware rather than for ways to change your child's responses, I
do not anticipate that the study will be uncomfortable for your child in any way. I will describe to him/her the general purpose of the study outlined above as well as the procedures according to which the research will be conducted. These procedures will include observing your child interacting with whatever courseware he/she would normally encounter during the school day and questioning him/her informally about his/her perceptions of and reactions to various instructional dimensions of that courseware. I also plan to interview your child—probably in a group and certainly in an informal, open-ended manner—several times during the study to gain deeper insights into the students' general reactions to these dimensions. These interviews will be audiotaped, and the tapes will be destroyed after they have been transcribed to ensure that no child can be identified by name as a participant in the study.

Other measures will also be taken to protect your child's anonymity. For example, all individuals' names will be changed in any written or oral presentations resulting from the study, and no one but the researcher will have access to the notes or transcripts upon which those reports would be based. Of course, your child's participation will be fully voluntary, and he/she may withdraw from the study at any time.

I hope that you will see fit to allow your child to participate in this research effort, which may one day contribute to the improvement of instructional materials for all students with learning disabilities. If you will simply read, sign, and date the attached form and have your child return it to his/her teacher as soon as possible, you will be helping me to begin my efforts in the very near future.

Thank you for your consideration of this matter.

Sincerely,

Delia Neuman

Delia Neuman
Consent Form for Parents/Guardians

MARBURN ACADEMY

CONSENT FOR PARTICIPATION
IN EDUCATIONAL RESEARCH

I consent to my child's participation in research entitled:

Learning Disabilities and Microcomputer Courseware:
Students' and Teachers' Interactions with Instructional Dimensions

Keith A. Hall or his/her authorized (Principal Investigator)
representative has explained the purpose of the study, the procedures to be followed, and the extent of my child's participation. I understand that this participation is fully voluntary and that I may withdraw my child from the study at any time.

I acknowledge that my child's participation will occur in accordance with the established policies and procedures of the Marburn Academy. The information obtained from and about my child will remain anonymous and confidential unless I specifically agree otherwise by placing my initials here:

__________________________

Finally, I acknowledge that I have read and fully understand this consent form. I sign it freely and voluntarily. A copy will be placed in my child's file.

Date: ___________ Signed: ___________________________ (Person Authorized to Consent for Participant)

Signed: ___________________________ (Principal Investigator or his/her Authorized Representative)
Letter to Teachers

789 South Remington Road
Bexley, Ohio 43209
March 15, 1984

Dear Teacher:

This spring and summer I will be conducting a research study at Marburn on the ways in which learning-disabled students perceive, react to, and interact with various instructional dimensions of microcomputer courseware and the ways in which their teachers perceive and use these dimensions to enhance students' learning. I am hoping that you will be interested in participating in this study, which I am undertaking in partial fulfillment of the requirements for my PhD in Computer Applications in Education and Training from The Ohio State University. My advisor at Ohio State, Dr. Keith A. Hall, is the principal investigator who is directing this dissertation research.

As you know, the microcomputer has fired the imaginations of many concerned with uncovering ways to tap and maximize the potentials of the almost 2 million school-age Americans identified as learning disabled. As promising as this tool is, however, little systematic and rigorous research has been undertaken to document and evaluate specific factors in educational software that enhance the learning of such students. And that is the purpose of my research— to examine the ways in which learning-disabled students and their teachers respond to a number of instructional dimensions thought to be critical in computer courseware: the design of screen displays, the kinds of questions students are asked, the kinds of feedback presented after responses, and so on. As an instructional designer, I am interested ultimately in learning how learning-disabled students interact with each of these dimensions so that future courseware can be designed to incorporate them more effectively.

The structure of my study will be consistent with an established methodology that is receiving renewed attention in educational research. Called "qualitative research," "naturalistic inquiry," and various other names, the method is designed to address the perceptions of those most intimately involved with educational issues—teachers, students, and others who deal with these issues daily.
With theoretical and procedural roots in anthropology and sociology, this method of inquiry may be quite different from the educational research with which you are most familiar. I (and many others!) believe, however, that this approach offers particular benefits that more common approaches do not address. As you read the brief procedural description of the study below, I hope that some of these benefits will become evident.

Because I am concerned primarily with students' interactions with the instructional dimensions of courseware, I will be spending the bulk of my time observing your students and questioning them informally while they work with whatever courseware they would normally encounter during the school day. I also plan to interview the students--probably in a group and certainly in a very informal, open-ended way--several times during the study in order to gain deeper insights into the students' general reactions to the instructional dimensions of courseware. Because I am also very interested in the ways in which teachers use courseware to enhance their students' learning, I also plan to talk with you informally about a number of issues related to the characteristics and uses of effective courseware for students with learning disabilities. And although I plan to spend as much time in all these activities as it takes me to develop a full and accurate understanding of the issues in question, I do not anticipate requesting excessive amounts of your or your individual students' time. A pilot study for this research that I conducted last spring according to these same procedures did not seem to be a burden on anyone involved.

A number of measures will be taken to ensure your and your students' anonymity and the confidentiality of the information you provide. For example, although all interviews will be audiotaped, the tapes will be destroyed after they have been transcribed to ensure that no one can be identified by name as a participant in the study. Additionally, all individuals' names will be changed in any written or oral presentations resulting from the study, and no one but the researcher will have access to the notes or transcripts upon which those reports would be based. Of course, your participation will be fully voluntary, and you may withdraw from the study at any time.
I hope that you will decide to participate in this research effort, which may one day contribute to the improvement of instructional materials for all students with learning disabilities. If you will simply read, sign, and date the attached form and return it to Mr. Forsythe as soon as possible, you will be helping me to begin my efforts in the very near future.

Thank you for your consideration of this matter.

Sincerely,

Delia Neuman

Delia Neuman
Approval for the Study

Ohio State University
Social & Behavioral Sciences
Human Subject Review Committee
Research Involving Human Subjects

Protocol No. 8480033
Original Review X
Continuing Review
Five-Year Review

Action of the Review Committee

With regard to the employment of human subjects in the proposed research entitled:
Learning Disabilities and Microcomputer Courseware: Students' and Teachers' Interactions with Instructional Dimensions

Keith A. Hall
M. Delia Neuman
Educational Theory and Practice

The Social and Behavioral Sciences Review Committee has taken the following action:

☑ Approved
☐ Disapproved
☐ Approved with conditions *
☐ Waiver of Written Consent Granted

* Conditions stated by the Committee have been met by the Investigator and, therefore the protocol is approved.

It is the responsibility of the principal investigator to retain a copy of each signed consent form for at least four (4) years beyond the termination of the subject's participation in the proposed activity. Should the principal investigator leave the University, signed consent forms are to be transferred to the Human Subject Review Committee for the required retention period. This application has been approved for the period of one year. You are reminded that you must promptly report any problems to the Review Committee, and that no procedural changes may be made without prior review and approval. You are also reminded that the identity of the research participants must be kept confidential.

Date 3-29-84
Signed: Thomas E. Hudson
(Chairperson)

Cc: Original - Investigator
File

HS-0258 (Rev. 7/81)
Dear Parent/Guardian:

Please sign the enclosed permission slip allowing your child to participate in my study of the ways in which Marburn students use the school's microcomputers in ongoing, day-to-day instruction.

I'd like to stress that your child's participation will not cut into his/her instructional time. Since the purpose of my study is to determine which aspects of computer courseware are most and least helpful to students with learning problems, it is important that I identify those aspects as they occur in normal, everyday use. Thus, the large bulk of my work involves simply observing the students' regularly scheduled use of the computer in a natural, unobtrusive way. Toward the end of the study I will be conducting brief interviews of small groups of students to learn their feelings and ideas about how to improve the courseware they use - an opportunity for self-expression that teachers and students in the past have found a valuable language-arts activity.

Without your permission, I will have to leave my "observation post" beside the computer when your child comes to use the machine, and I will have to exclude him/her from the final interviews as well. Since the large majority of parents/guardians have given their permission for their children to participate, I'm afraid such exclusions would in themselves draw undue attention to your child. Of course, I will respect your decision in this matter and do all that I can to minimize any discomfort for your child should you withhold your consent. However, I'm hopeful that you'll agree that participation will be a positive experience for him/her and that you'll sign the form and return it to Marburn at your earliest convenience.

Thank you very much.

Sincerely,

Delia Neuman

DN/cf
APPENDIX B
INTERVIEW SCHEDULES
Schedule for Headmaster

1. Could you talk in general terms about what you think are the advantages of CBE for LD children and what you find to be the disadvantages of that approach?

2. When I began this study almost a year ago, you had four computers in instructional use and planned to add more. But you haven't added more. Why?

3. Until now, you've done most of the screening and selecting of courseware for Marburn. Do you see a need for someone to "take charge" of CBE here—to find courseware, encourage teachers, and so on? Do you think CBE is worth that much effort?

4. Why do you reject some pieces of courseware and accept others? What things seem most important?

5. Have you ever used any of the commercially available checklists or services to evaluate courseware or do you find those just not useful to you at all?

6. What would be most helpful to your teachers in courseware packages? What should be in the documentation to help the teachers use packages effectively?

7. If you had at your disposal the world's most skilled instructional designer and unlimited funds, what are the elements of the package you would want that person to design for Marburn?

8. What would you tell an instructional designer today about a program that would be really helpful to your students for use on your current equipment?
Schedule for Teachers

1. Am I getting an accurate picture of what really happens when the students use computers or does my presence change things?

2. What value do you see in using the computer with your students? What negative aspects?

3. You have/don't have a computer in your own room. Why is that? Where is the best place for a computer to be located?

4. What do you think is the best use of the computer in your classroom? Drill and practice? Tutorial?

5. Do you think the students learn from working on the computer?

6. Have you seen any evidence that students transfer what they've learned on the computer to other tasks?

7. How do you learn about/obtain the courseware you use? Is that adequate?

8. Have you looked at any courseware and rejected it? Why? What makes you select/reject [specific packages]?

9. As you see it, what are the limitations of the courseware you currently use with your students?

10. What good and effective things have you found in the programs you use? What doesn't work?

11. What kinds of courseware do your students need?

12. You've mentioned that the courseware often can't stand on its own and that the students need auxiliary materials. What kinds of things do you mean?

13. Should courseware come with correlated worksheets, overheads, etc., or would you rather provide them yourself?
14. How good is the computer at helping you individualize your instruction? Are the programs flexible enough to allow you to meet students' needs?

15. It can take a lot of time to learn a program and decide how to implement it. Do you feel it's worth your time to do that?

16. Are the students who are/aren't attracted to the computer the same ones who are/aren't attracted to other things or does the computer have a unique attraction for any of them?

17. Are the students more or less distractible when using the computer or doesn't it make a difference?

18. What does/doesn't working on the computer do in relation to students' expectations for success or failure?

19. Do you think using the computer promotes independence in your students? Leadership? Interpersonal skills?

20. Do girls and boys react differently to the computer? How?

21. Some of your students seem to need to talk constantly and are very dependent on the social aspects of the classroom environment. How does the computer fit in for a child like that?

22. I have/haven't seen you use the computer to develop social skills, to help students learn to work together. How effective is it for that?

23. Do you see any potential for using the computer as a diagnostic tool? To determine performance levels? To uncover difficulties?

24. I've often seen you teach from the computer. Do you think it works as a teaching device?

25. I've noticed that you often have to teach the students how to work programs rather than letting them get started independently. If you felt students could begin independently, would you let them do so or do you see it as part of your teaching role to get them started in whatever they do?
26. Often the students can't/don't read the directions. What about the amount of reading these require? Would it help if there were fewer instructions and more examples?

27. When the students are made to read the directions, they seem to be able to read the individual words fairly well. But do they understand the meaning of what they read?

28. What do you think is reinforcing for the students—graphics, getting high scores, going up levels?

29. What do you think of using the timed programs for your students? Are they too fast? A source of undue pressure?

30. What about the typing requirements in some programs? Is that a problem?

31. What does it mean when the students say something is "boring"? Is that an accurate statement? The "in" thing for an adolescent to say? A euphemism for "I don't understand"?

32. The students often don't seem to remember or even notice some of the hints that you provide when you're introducing a program. Should there be hints in courseware? Would students use them?

33. The students all say they love games. What do you think about that? Does it trouble you to use competition as a learning device?

34. Many of the students say they'd like to have voice with the programs. Do you think that's a good idea or would it be too distracting?

35. How do you determine student assignments—who uses the computer, the programs they're to use, the levels within the programs, the time allotment, etc.?

36. I've noticed that your pattern of assigning students is [varies]. How did you arrive at that method?
37. How do you integrate the students’ computer experiences with the other things going on in the classroom? Do you try to tie the courseware into students’ IEP goals?

38. Would you like suggestions about how to integrate the courseware into your ongoing instruction or do you feel you’ve mastered that?

39. What strategies (if any) do the students use to answer questions or to get through things they don’t understand?

40. Have you taught them these strategies or have they developed them on their own?

41. When a program offers a strategy—like regrouping—some students seem to use it all the time and others not at all. Is that lack of selectivity a problem?

42. I’ve seen students count on their fingers to answer some problems. Is that OK or is it reinforcing a strategy you’re trying to fade?

43. Often the students seem to respond to questions randomly, to be able to do the individual tasks in a program without seeing the whole or learning what they’re supposed to learn. Is that true? How could courseware help with that?

44. Sometimes a program’s stress on following correct procedures seems to obscure an understanding of the whole. Is that a problem?

45. Would it be better if students could work entire problems on the screen rather than just putting in their answers?

46. Is the corrective feedback in the programs generally adequate for your students?

47. In the programs that have automatic branching based on student performance, are the steps between levels small enough for your students to branch to higher levels successfully?
48. Is there enough practice within each level for the students to master the concepts?

49. What should instructional designers know to make courseware more interesting and effective for your students? How can courseware be better? What advice can you offer?

50. Is there anything I haven't asked you that I should have?
Schedule for Students

1. Who has/uses a computer at home? What for?

2. What do you think about the things you use at school? How do they compare with what you use at home?

3. What do you like/not like about using the computer at school? What programs do you like/not like?

4. What's the best program you use at school? What do you like about it?

5. Does it help you learn when you use the computer at school? As much as, say, workbooks and worksheets?

6. What kinds of things do you learn?

7. Is school more interesting because the computer is here?

8. Do you think you'd miss the computer if it weren't here? Why/why not?

9. Is it easier or harder to pay attention to the computer than to other things at school?

10. Do you like working by yourself at the computer? With other people?

11. Do you get enough time at the computer? Too much/little?

12. Should everyone have a computer at school?

13. Most of the time people don't read the introductions or directions when they use new programs. Why?

14. What about the directions? Are they good? Too hard/easy enough to read?

15. When you look at the screen, what grabs your eye first?

16. When you get something wrong, does the program tell you enough about why it was wrong so you can fix it?
17. What do you do when you don't understand something on the computer? Do you ever try to figure things out for yourself?

18. What do you think about the programs that make you work against time?

19. What do you think about the typing you have to do in some programs?

20. Which do you like best--graphics, "wows" and "supers," going up levels, getting high scores?

21. How do you feel when you see that big red "X" that tells you you got something wrong?

22. Some people use the regrouping option all the time and some never use it. Which kind of person are you? Why?

23. Many people tell me they'd like to have sound with the programs. What do you think about that?

24. Most people who write programs for schools never talk to kids about what they like and don't like, what works and doesn't work. So here's your chance. If you could tell these people two things to do to make the programs better, what would you tell them? Why?

25. What haven't I asked you that I should have?
APPENDIX C
CODING CATEGORIES
<table>
<thead>
<tr>
<th>Code</th>
<th>Gloss</th>
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</thead>
<tbody>
<tr>
<td>COM-D</td>
<td>Competition--direct</td>
</tr>
<tr>
<td>COM-I</td>
<td>Competition--indirect</td>
</tr>
<tr>
<td>CON-A</td>
<td>Context--administrative</td>
</tr>
<tr>
<td>CON-C</td>
<td>Context--classroom</td>
</tr>
<tr>
<td>CON-G</td>
<td>Context--general</td>
</tr>
<tr>
<td>CON-P</td>
<td>Context--physical</td>
</tr>
<tr>
<td>CON-R</td>
<td>Context--relationship</td>
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<tr>
<td>CON-S</td>
<td>Context--student</td>
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<tr>
<td>CWR-G</td>
<td>Courseware--general</td>
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<tr>
<td>CWR-AR</td>
<td>Codes for individual courseware</td>
</tr>
<tr>
<td>CWR-BS</td>
<td>Packages</td>
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<tr>
<td>CWR-BU</td>
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<td>CWR-EE</td>
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<td>CWR-MA</td>
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<td>CWR-WW</td>
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<td>FDBK-BU</td>
<td>Codes for feedback for packages</td>
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<td>FDBK-MI</td>
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<td>FDBK-MO</td>
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<td>IMP-I</td>
<td>Implementation--integration</td>
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<td>IMP-N</td>
<td>Implementation--need</td>
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<td>IMP-R</td>
<td>Implementation--reason</td>
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<td>IMP-S</td>
<td>Implementation--schedule, strategy</td>
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<td>KIND</td>
<td>Kind--courseware preferred</td>
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<tr>
<td>LIKE</td>
<td>Like--like, dislike</td>
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<td>Code</td>
<td>Gloss</td>
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<td>---------</td>
<td>--------------------------------------------------------</td>
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<td>METH</td>
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<td>MO-DIS</td>
<td>Motivation, distractibility</td>
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<td>REC-R</td>
<td>Recommendation—researcher</td>
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<td>REC-S</td>
<td>Recommendation—student</td>
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<td>REC-T</td>
<td>Recommendation—teacher</td>
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<tr>
<td>REIN-G</td>
<td>Reinforcement—graphics and sound</td>
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<td>REIN-I</td>
<td>Reinforcement—intrinsic</td>
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<td>REIN-V</td>
<td>Reinforcement—verbal</td>
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<td>RES-I</td>
<td>Response—individual, random</td>
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<td>RES-K</td>
<td>Response—keyboarding requirement</td>
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<tr>
<td>RES-P</td>
<td>Response—problem (conceptual)</td>
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<tr>
<td>RES-S</td>
<td>Response—speed</td>
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<tr>
<td>SKILL</td>
<td>Skill—learned, not learned</td>
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<td>ST-D</td>
<td>Student—description</td>
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<td>Stimulus—graphics and sound</td>
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<td>STIM-P</td>
<td>Stimulus—prompt</td>
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<td>STRAT-A</td>
<td>Strategy—academic</td>
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<td>STRAT-C</td>
<td>Strategy—coping</td>
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<td>STRAT-T</td>
<td>Strategy—teacher</td>
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Sample Working Matrix

Matrix F—Elicitation of the Response

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<thead>
<tr>
<th>RESPONSE CHARACTERISTICS</th>
<th>Positive Aspects</th>
<th>Negative Aspects</th>
<th>Rsrchr's Remarks</th>
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<tbody>
<tr>
<td>Conceptual Demands</td>
<td>Teacher A</td>
<td>Teacher B</td>
<td>(etc.)</td>
</tr>
<tr>
<td></td>
<td>[Data extracted from fieldnotes, transcripts, and documents]</td>
<td>[Explana-notes, preliminary conclusions, suggestions of themes and patterns]</td>
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<tr>
<td>Hints</td>
<td>[as above]</td>
<td></td>
<td></td>
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<tr>
<td>Keyboarding Requirements</td>
<td>[as above]</td>
<td>[as above]</td>
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</tr>
<tr>
<td>Speed/pacing</td>
<td>[as above]</td>
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</tr>
</tbody>
</table>
Sample Meta-matrix (Narrative)

Students' strategies--academic

Middle Division girls

RESPONSE

S1--Anne A.
STRAT-A
6F-18  
[Description of Anne's interactions with a response characteristic during the sixth fall observation session; found on page 18 of the fieldnotes]

STRAT-A
2F,3  
[Segment of transcript related to Anne's interactions with a response characteristic; taken from the second fall interview, transcript page 3]

RES-P
12F-47  
[Description of a problem Anne had responding during the twelfth fall observation session; page 47 of the fieldnotes]

REC-S
2F,6  
[Anne's recommendation for improving something about a response requirement; page 6 of the transcript of the second fall interview]

S2--Beth B.
RES-K
29F-131  
[Description of Beth's keyboarding technique; fall observation session 29, page 131]

RES-P
29F-131  
[Description of a problem Beth had, perhaps related to her keyboarding technique, from the same observation session]
S3--Cathy C.
ST-D
11F-87  [Description of Cathy and her ease of responding to a question during fall observation session 11, page 87]

RES-S
4F,1   [Segment of transcript related to Cathy's opinions of a timed program, taken from the fourth fall interview, transcript page 1]
Sample Meta-matrix (Chart)

Students and Responses--Conceptual Demands

Middle Division girls

<table>
<thead>
<tr>
<th>STUDENT</th>
<th>SITUATION</th>
<th>STRATEGY</th>
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<tbody>
<tr>
<td>S1--Anne A.</td>
<td>[Descriptions of all the encounters Anne was observed to have with or the opinions she expressed about the conceptual demands of response options in courseware used throughout the fieldwork]</td>
<td>[Descriptions of all the strategies Anne was observed to use while interacting with the conceptual demands of response options]</td>
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<tr>
<td>S2--Beth B.</td>
<td>[as above]</td>
<td>[as above]</td>
</tr>
<tr>
<td>S3--Cathy C.</td>
<td>[as above]</td>
<td>[as above]</td>
</tr>
</tbody>
</table>
LIST OF REFERENCES


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Leclair, N. (1984). Marburn Academy Curriculum Philosophy. (Available from Dr. Norma Leclair, Program Director, Marburn Academy, 1680 Becket Avenue, Columbus, OH 43220)


