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ABSTRACT

Student control of learning is interpreted as student self-teaching, and a plan to give students teacher training is outlined. The first step of the plan is self-management in which the students are given a strategy for curriculum decision making and have the reponsibility for applying that strategy. Two interactive computer programs are included as instructional alternatives within the self-management system on the rationale that computers are responsive yet still under student control and are therefore uniquely adapted for self-controlled learning environments. Students in fourth and fifth grade were able to effectively manage their learning in elementary mathematics and apparently learned faster and retained material better then a comparative group of students. (Author)

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Self-Managed Learning Using CAI

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Abstract

Student control of learning is interpreted as student self-teaching, and a plan to give students teacher training is outlined. The first step of the plan is Self-Management in which students are given a strategy for curriculum decision-making and have the responsibility for applying that strategy. Two different interactive computer programs were included as instructional alternatives within the Self-Management System on the rationale that computers are responsive yet still under student control and are therefore uniquely adapted for self-controlled learning environments. Students in fourth and fifth grade were able to effectively manage their learning in elementary mathematics and apparently learned faster and retained material better than than a comparison group of students.

Self-Managed Learning Using CAI

Teaching of any specific knowledge content or set of skills involves a large number of decisions concerning sequencing of material, mode of presentation and diagnostic evaluation. There has been increasing interest recently in taking these teaching decisions out of the hands of the school management and putting them under control of the students themselves. The possible benefits of such student control are several. The student is in a position to have more relevant information about his or her state of learning than anyone else and thus, might be expected to make better decisions. Allowing students to control certain aspects of instruction frees the teacher to perform other more essential duties. The student who acquires the ability to control his learning in school will be better equipped to face learning situations independently outside of school. Finally, allowing an individual to control his or her own activities and achievement, rather than give such control to a higher authority is more consistent with the standards of our free society.

Unfortunately, when students are allowed to teach themselves the result is not always a positive learning outcome. For examples, Fry (1972), Atkinson (1972), Olivier (1971) and Judd, Bunderson and Bessant (1970) all found significantly inferior performance with instruction that was under learner control. It is perhaps not surprising that the ability to teach, an ability which schools of education spend four or five years inculcating, does not appear automatically in naive students. Although not surprising, it is disappointing that the choice appears to be between student-controlled instruction and effective instruction.

Some experimenters, however, have shown positive outcomes for student-controlled instruction (Grubb & Selfridge, 1964; Newman, 1957; Campbell & Chapman, 1967). The distinguishing characteristics of these successful examples of student control seem to be highly able and motivated students and non-student controlled teaching alternatives which are mediocre and uninteresting (see Judd, O'Neil & Spelt, 1974). In other words, because the students were interested and of generally high aptitude and because the alternative "teachers" were not very competent, the students out-taught the system and were better off controlling the instruction themselves. If the best available teacher is the student, then student control produces the best learning.

Resolution of the dilemna between effective instruction and student-controlled instruction then would seem to be accomplished by training students to make better instructional decisions, that is, to be better teachers. A study by Campbell supports this speculation in that only students who were shown how to use the target instructional materials derived benefits from controlling their own learning (Campbell, 1964). A student trained to teach him or herself might be expected to produce better learning outcomes than a similarly trained external teacher because of greater time for and interest in the teaching task and greater knowledge about the state of the learner.

The study reported here is a test of a procedure to teach elementary school students to make detailed instructional decisions, and thereby control their own learning, in mathematics. In one unit of instruction, students were given a detailed set of rules to be used to guide instructional decisions. They then applied these rules to guide their own progress through the unit. In this way, students did not actually control their instruction, but using the experimentally imposed rules they managed it. The immediate goal of this study was to determine if students could consistently and effectively apply reasonable teaching strategies in making instructional decisions. The long-term goal of this line of research is to use this Self-Management as an intermediate step in training students to effectively control their own learning.

Instructional self-management in this study involved combining and sequencing three alternative learning modes in order to acquire a set of well-defined objectives. Rules for selecting among the different possible modes were based on measured student ability and on previous training. Two of the available instructional alternatives were interactive computer programs. It was hypothesized that some of the special properties of computer instruction would prove especially beneficial in developing student independence.

One of the difficulties confronted in operationalizing learner control is the normal educational procedure which makes important aids to learning available only if control is surrendered to an external agent. Responsiveness to student behavior, demonstrations of difficult procedures to be learned and diagnostic evaluation of performance are important characteristics of effective education, but they are normally available only through interacting with a teacher who tends to define and control the instruction. Computer programs, on the other hand, can offer some of the features of responsiveness, diagnosis and demonstrativeness without demanding control over the interaction. A computer program is called at will, does what it is told to do, can be ignored and can be turned off at the student's pleasure. Human teachers have none of these characteristics. It is in this role as genie, providing crucial learning services at the will of the master student, that computers might be valuable in learner-controlled instruction.

In summary, elementary school students were given a set of systematic rules which they used to manage their instructional progress through a unit of a mathematics curriculum. These rules determined when each of three instructional options would be used. Two of these options were interactive computer programs which were designed to provide the informative, graphic responsiveness important in learning, yet be under student control. It was hypothesized that this Self-Management system would be a feasible step in developing procedures for teaching students to effectively control their own learning. The eventual goal is to obtain the advantages of student control without sacrificing efficiency in learning.

Method

Instructional treatments. Unit E Multiplication of the Individually Prescribed Instruction curriculum (IPI, Lindvall & Bolvin, 1967) was selected as the target unit for Self-Management. The unit is divided into seven separate objectives. The first four objectives develop the algorithm for multiplying multi-digit factors, culminating in objective four in which the student is called upon to multiply two digit numbers by four digit numbers. Objective five uses the commutative principle as a basis for an answer checking procedure, and objective six consists of procedures for finding products of more than two factors. Objective seven covers verbal problems and was not included in Self-Management.

Three instructional treatments were used in the Self-Management system. The first was the standard set of IPI curricular materials. These are workbooks, one to an objective, which use a programmed instruction format to lead the student from his or her entering knowledge level to the expertise required to master a test over the objective. The booklets are not meant to be single coherent instructional sequences. Rather, it is intended that parts of the total material be effective in isolation and teachers are encouraged to assign only the pages that will be helpful for an individual student. The booklets are used independently by the student without teacher intervention.

The second treatment in the Self-Management system was an interactive computer program which provided practice problems from the unit. A problem was presented at the computer terminal, the student computed an answer and typed it into the machine. The program then informed the student whether the answer was correct or incorrect. If incorrect, the program erased the student's wrong answer and "demonstrated" the correct solution in its place. This demonstration consisted of a presentation of each step of the solution in the correct order and with realistic timing, much as a teacher would demonstrate a solution on a blackboard. After answer feedback a new problem was presented. If the student provided correct answers, the program branched to more difficult problems in the unit and if the student gave incorrect answers, the program branched to prerequisite problem types. Although this branching strategy was logically complete, and could operate without human assistance, it could be over-ruled by the student through an option which allowed the student to choose for practice any objective in the unit, whether or not the program strategy would have selected it. The structure and terminology used in the practice program matched that of the IPI unit.

The third instructional treatment was a computer program which provided the answer demonstrations separate from practice and completely under student control. After accessing the program, the student specified the type of problem solution that he or she wished to be demonstrated. The program then requested numerical input to define a problem of the type requested. Once the student specified the problem, the program completed the solution using the same demonstration routines as the practice program. A new problem could then be specified by the student.

Procedure. Students entered the Self-Management system when they reached the E-Multiplication Unit in their own individual progress through the curriculum. Upon entering the Unit, students took a pretest over each objective within the unit. Objectives not mastered were then studied using the Self-Management system. Rules for Self-Management were described in a set of charts which explained which of the three instructional treatments was appropriate at each instructional decision point. An example of one of these charts is shown in Figure 1.

These charts identified certain decision points at which time a new instructional treatment could be selected or instruction in an objective could be terminated. These decision points occurred after the pretest and after sessions on the practice program. At these points, information is available in terms of the correct answer rate for problems from the objective, and this information can be the basis for decisions about further instruction. The general strategy underlying these rules was this: low skill, as indicated by a low accuracy rate, called for the direct instruction of the IPI booklets; intermediate skill levels called for the more inductive learning which was the aim of the practice program; and high skill (i.e., high accuracy) was grounds for advancing to the next skill.

Specifically, if the student missed greater than 50% of the problems seen on pretest or practice session, he or she was directed toward a short workbook assignment and/or work with the Demonstration program. The student then returned to the practice program and if the failure rate was still below 50%, a longer workbook assignment was indicated. If performance on pretest or practice was greater than 50%, then the student was directed to continue on the practice program, and finally if performance was greater than 80%, the student was directed to proceed to the next objective.

After the unit pretest and before instructional work began, each student was given 10 minute orientation session with the experimenter in which the Self-Management system and use of the prescription charts was explained. Students then began work. On the second instructional day the experimenter reviewed the Self-Management procedure and gave the student an opportunity to ask any questions that might have arisen on the first day. This review session also required about 10 minutes. From this point on the student worked through the unit independently, self-prescribing instruction using the management charts. Students met with the experimenter periodically, at which time the experimenter examined, but did not comment upon the instruction which the student had selected.

All student work in the school, whether under the Self-Management system or not, was self-scheduled such that each student determined how long he or she would work on assignments in mathematics, reading, science and spelling (Stone & Vaughan, 1975). The amount of time spent in the Self-Management system, however, was artifically reduced somewhat below that spent on other mathematics units. This was due to a restriction placed on terminal usage which allowed a single student no more than 20 minutes a day on the computer as opposed to the average of 40 to 50 minutes spent in mathematics in general. This reduction in possible time spent led teachers to make two parallel math assignments -- one Self-Managed by the student in the E-Multiplication unit and one teacher managed in another unit. Thus, often Self-Managed students were working in two areas of mathematics simultaneously.

At the end of the school year a retention test which paralled the E-Multiplication unit posttest was given to students who had completed the unit either in the Self-Management system or under teacher guidance.

Subjects. The Self-Management system was made available to all comers in one fourth grade classroom and one fifth grade classroom of a suburban elementary school. Students in this school are at or slightly above national norms for mathematics achievement. Fourteen fourth graders and 5 fifth graders completed the unit using the Self-Management system. Five fourth graders and 4 fifth graders completed the unit under the normal teacher prescription procedures. These students failed to use Self-Management either because they mastered the unit early in the year, before the Self-Management system was available or because they began the unit when the experimenter was unavailable for orientation. Thus, the Self-Managed group can be compared against a standard instruction group of students, but assignment to groups was not experimentally controlled and equivalence of the two should not be assumed.

Results

Self-Management operated smoothly with little evidence of delays or problems. Students were able to follow the charts and coordinate the different instructional alternatives. The only general complaint from teachers was that assignments for students in Self-Management were not time consuming enough to keep the students busy. One student was denied access to all computer work, and therefore, removed from the Self-Management system, when it became clear that his trips to the computer terminals were used as opportunities to roam around the school. Only twice were failures in the application of the Self-Management rules detected. In both cases students determined that they had finished work on an objective before the rules would have so specified.

By way of comparing the ability level of the Self-Managed and the standard instruction students, the average number of target objectives failed on the pretest was computed for the two groups. The figures are almost identical -- 4.2 skills for the Self-Managed students and 4.3 for the standard instruction comparison group -- suggesting that the two groups were comparable in their pre-instruction knowledge of unit material.

Averages for the number of days required to complete each unit objective for both Self-Managed students and the comparison group are shown in Table 1. With the exception of skill 4, it is clear that the Self-Management students required no more instructional days to master the material than the standard instruction students. Averaging across all objectives, except number 4, the Self-Managed students required 1.4 days to master while the comparison group took 1.5. Given the strong, but unfortunately undocumented, indications that Self-Managed students were spending less time daily on mathematics, the equal number of days per skill suggests that the Self-Management system produced mastery in less instructional time than did the standard instruction.

Objective 4 is an exception. Here Self-Managed students required more days and probably more instructional time to master than did the standard instruction. The target of this objective is the algorithm for multiplying a two digit number times a four digit number, the most complex operation in the unit. Examination of individual prescription protocols for this objective indicated that the Self-Managed students tended to spend several days on the practice program, getting more than half of the problems correct, but still failing to meet the completion criterion. Only 4 of 11 students prescribed long booklet assignments for themselves. The standard instruction group, on the other hand, all were assigned extensive booklet work and met the mastery criterion immediately after this assignment.

End-of-year retention tests were available for 15 Self-Managed students and 5 standard instruction students. The percentage correct on these tests for each target objective and for all objectives is given in Table 2. Since students mastered the unit individually throughout the year, the period between mastery and retention test is different for each student. The average length of this period for Self-Managed students was 98 days, for standard instruction students it was 107 days. Table 2 indicates general high retention for both types of instruction, with the Self-Managed students remembering somewhat more than the others across all skills. It should be noted that the greatest retention difference favoring Self-Management was on Objective 4, the objective which required more time to acquire in Self-Management.

Discussion

The effort reported here is only a small part of a program to develop self-teaching students. What has been shown is that students can consistently and effectively follow an instructional strategy on their own, without outside assistance. The result is an acquisition rate as high, or perhaps higher, and retention as good, or perhaps better, than that of teacher controlled instruction. Since the teacher controlled instruction and the Self-Managed system differed in several ways (such as, use of computers, prescription rules used, person responsible for making prescriptions), this study does not allow an exploration of the mechanisms involved in successful Self-Management. Nevertheless, this work does serve as a feasibility demonstration, that elementary students can manage their own learning.

Self-Management is viewed as the first of perhaps four stages in the apprenticeship of self-teachers. The second stage is the understanding of the general, conceptual rationale for specific instructional procedures. For the procedures used in the present Self-Management system, for example, this would mean knowing in general that practice as a learning experience is more effective when some minimal level of skill has already been attained and that below this level more direct, expository instruction will be more efficient. This general grasp of what might be called the principles of teaching is the basis of the third stage of the apprenticeship -- the application of the principles to new learning problems. At this time the student is faced with new educational goals and must derive a specific learning strategy based on his or her understanding of general teaching principals.

Finally, at the fourth stage the student becomes a journeyman teacher and has what could indisputably called knowledgeable self-control over learning. At this stage the student is able to systematically manipulate the teaching principles to suit his needs. Flawless formulas for teaching do not exist. The good teacher, including the good self-teacher, must creatively apply knowledge from past experience to confront new problems and must carefully observe the effects of tentative solutions in order to improve the knowledge base. Self-Managed learning of the fourth objective of the E-Multiplication unit illustrates the kind of adaptiveness good teaching requires. Here the generally effective strategy for organizing instructional treatments produced delays in learning. With such a negative outcome, it would be expected that the good self-teacher would adapt the general strategy for future use, perhaps by always treating very complex skills with direct expository instruction first, or by adjusting the accuracy threshold for moving from expository instruction to practice upward from 50%.

This discussion of the development of student-controlled teaching is highly abstract and optimistic. It is not at all clear how to induce the high-level abilities represented by stage four, nor is it clear that even professional teachers often perform in such a way. However, being less ambitious, it is possible to consider concretely how the Self-Management demonstration could be extended. After the student has become a Self-Manager, instruction in generalizable principles of instruction can begin. It is proposed then, that students be taught the role of expository instruction, of demonstrations, of practice and the reasons why these different treatments are arranged as they are in the Self-Management System. The importance of an accurate assessment of ability must also be taught.

In the abstract it would be very difficult to teach these matters in a meaningful way, but to a student who is already self-managing, the material is immediate and concrete. We are presently developing instruction which uses the Self-Management system as a base and directs the student to such questions as "Why should you use the practice program here?" "With this score on the pretest do you think an IPI booklet or the practice program would be best?" A test of the effectiveness of this instruction would consist of allowing students complete freedom in controlling their instruction over a new portion of the curriculum. The hypothesis entertained is that students who have experience in Self-Management and have explored the rationale of the system will attack a new learning problem differently and more effectively than students without such experience.

Finally, it must be acknowledged that no evidence was obtained in this study to support the hypothesis that the responsive nature of CAI makes it an important component in successful student management. A test of this proposition would require a comparison of Self-Management with and without computer experiences as instructional alternatives. Such a test could easily be made and would be valuable.

In summary, we feel that learning which is student controlled has both intrinsic value, and potential extrinsic value arising from the faster more efficient learning that can result from student control. The student is in a position to have more motivation and more knowledge relevant to his or her own learning than any other individual and therefore, can be the best teacher. Effective self-teaching, however, cannot be expected to occur automatically without training. We propose a type of apprenticeship in which the student is trained to assume successively more responsibility for his or her own learning. This study represents a successful first step in this training procedure.

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Table 1

Average Number of Instructional Days Required to Complete Objectives in Self-Managed Instruction and Standard Instruction

Objective	1	2	3	4	5	6	Total	Total Without 4
Self-Managed $n = 20$	1.1	1.5	1.9	4.2	1.6	1.3	1.8	1.4
Standard $n = 9$	2.0	1.7	1.0	1.6	1.6	1.0	1.5	1.5

Table 2

Percent Correct on Each Objective on End-of-Year Retention Test for

Self-Managed Instruction and Standard Instruction

Objective	1	2	3	4	5	6	Total
Self-Managed n = 15	100	96	97	88	97	91	95
Standard n = 5	97	90	77	67	97	80	84

Figure 1

Chart Used by Self-Management Students to Guide Decision-Making in E-Multiplication

E MULT.		PRESCRIPTIONS
SKILL 1		
Look at your Pretest for Skill 1:	If you Pretested out of Skill 1 →	go on to Skill 2
	If you have more Correct than Incorrect →	go on P.MULT on Skill 1 for two sessions
	If you have more Incorrect than Correct →	Do pp. 2 & 3 in your Math booklet; then go on P.MULT on Skill 1 for two session.
Use only when you first start working on Skill 1.		
Look at how well you did on P.MULT:	If you passed Skill 1 on the computer →	go on to Skill 2, do not take a CET yet, unless you have pretested out of 2. If you presteted out of two, take CET for Skill 1
	If you have more Correct than Incorrect →	go on P.MULT on Skill 1 for two sessions.
	If you have more Incorrect that correct →	Do pp. 1-8 in your Math booklet; then go on P.MULT on Skill 1 for two sessions.
Keep using these prescriptions until you pass Skill 1.		