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Learning as the Constant and Time as the Variable

Gordon H. Flammer

The lecture method of teaching, which is the foundation of the conventional approach to education, leaves some very compelling questions unanswered. How can educators truly develop each *individual* student to his ultimate potential? How can the present teacher-centered system be changed to a learner-centered system? How can one get away from the false and unjust concept that some people are slow learners or incapable of learning when, in most cases, the problem rests in the accumulated ignorance allowed by the present educational system? How can educators overcome the problem of cumulative ignorance over the educational life of the student? How can instruction be individualized?

How can the role of the teacher be changed from that of a dispenser of information to that of a diagnostician and prescriber of learning experiences for each individual student? How can the feeling be overcome that learning can take the place only in the classroom? How can large numbers of students be taught as effectively as small numbers and instruction still be individualized? How can educators design the learning process to permit more time for personal contact with the individual student? How can modern technology be used to aid the learning process and to conserve the teacher's time for individualized instruction?

How can educators escape from the evils of the present grading system with its designed failures, its accumulated ignorance factor and its emphasis on material regurgitation? How can tests be used for diagnosis and learning rather than grading? How can grading be made objective? How can learning at mastery levels be made the constant and time be made the variable?

Individualized Instruction

Individualized or self-paced instruction appears to answer most of these questions in ways acceptable to both teachers and students—and at a time when the public is beginning to cry for an “Age of Accountability” in education.

It is significant too that recently many large corporations are looking with great interest at the billions of dollars spent for education. Using individualized instruction, some of them have actually guaranteed and *demonstrated* one year of student learning at standards specified by public educational institutions for prices less than half the current cost of public education (where the only guarantee is that a student will occupy a seat in a classroom for one year).

The lecture method is popular because it is generally considered to be the most efficient method for teaching large numbers of students—from both a time and a financial viewpoint. The lecture method assumes that all students are equally ready and receptive for content at the same time, since everyone receives identical treatment. It assumes that students learn far better in the classroom than anywhere else. These assumptions

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are not supported by educational research or by experience.

This article discusses the application and results of behavioral systems design to individualized instruction in an elementary fluid mechanics course and answers some of the questions about self-paced instruction. Many of the ideas presented came from a seminar conducted by Dr. Donald Stewart, director of State Services, Inc., of Westminster, California. The theme of this seminar was that individualized instruction—with learning the constant and time the variable—is not only practical, but is considerably more ethical and humane than the lecture method with its cumulative ignorance and designed failures.

Behavioral Systems Design

The application of behavioral systems analysis (systems engineering) to design of my elementary fluid mechanics course (the second of a three-quarter sequence) followed the recommendations of Stewart, Banathy, and others (see references).

1. About 80 terminal objectives for the course were decided upon in consultation with colleagues teaching the same course. These objectives were stated in behavioral and measurable terms (Mager, 1962) and were given to each student at the beginning of the course, along with a flow-chart showing how the objectives were to be approached concept-wise.

2. Tests (evaluation instruments) were designed to measure each of the "measurable terminal objectives." The test item simply asked the student to do precisely what the terminal objective said he should be able to do on a one-to-one basis.

3. A pre-entry test was next designed to measure the level at which each student entered the course in order to start him at precisely that level. The results of this test were a real eye-opener.

4. Learning units were designed to help the student move at his own pace from his pre-entry level to the desired terminal behavior level. Each unit included the terminal objectives stated in behavioral terms, a list of examination questions which measured each of the terminal objectives specifically and from which the tests were to be taken, suggested reading, thought questions covering the unit (akin to programmed instruction), and a brief statement of professional applications. Since each student moved at his own pace, lectures were impossible and recorded discussions on tapes were checked out to each student when he was ready. Dial access was not available, but it would have been ideal for this. One day a week, small group discussions were held, with the class divided by learning units. These groups were assisted by the professor, a teaching assistant, and students who had passed the given unit. The other class periods were used for testing.

5. The laboratory used realistic, nontrivial fluid mechanics problems, and students role-played the part of professional engineers working to satisfy a client. They were given "professional" experience in calibrating laboratory equipment, selecting and using measuring devices, explaining flow phenomena, and conducting a research project stressing the engineering approach to problem solving and creative thinking. Subgrade reports were returned for correction until they met the specified standards.

6. Each learning unit was evaluated by each student upon completion, as well as by the teaching staff. These evaluations, along with the tests, were studied to detect learning problems for revising the unit.

7. The grading system used was A, B, Incomplete. B was given when a student had completed all units at the 90% level; A was given when he had spent 15 hours helping others complete units he had completed. Incomplete

was needed only because of the fixed time quarter system. Tests were used for diagnosing student learning problems, prescribing learning experiences, and measuring student progress. They were not used for grading. If a student's score was below 90% (any concept mistake was minus 11 points), he was given help on his learning problems in preparation for retaking the test.

Objections to Individualized Instruction

1. *Individualized instruction is not practical because of the time required of the instructor.* Individualized instruction does not mean that each student gets individual one-hour lectures. In reality, the teacher's role changes from a presenter of content to a diagnoser of learning problems, a designer and manager of learning experiences for the individual student. The instructor does not do what media and other educational aids can effectively do; in fact, media (textbooks, handouts, films, dial access, audio-tutorial, computer-assisted instruction, etc.) reach their highest significance in individualized instruction. Teaching assistants and secretaries can perform less important tasks to release the teacher's time for diagnosing individual learning problems and prescribing for them—his most valuable and exciting role. The time required for individualized instruction—correcting and analyzing tests, assisting in small group discussions, and answering individual questions—is about the same as that for the lecture method, once a course has been designed and proven, but during the initial design of a self-paced course, a significant amount of time is required. The first time or two through a course unforeseen learning problems are detected from both student and staff evaluations and are designed for in the amended learning unit.

2. *Individualized instruction is not practical because of the time required by the student.* Individualized instruction is carefully designed learning which allows for individual differences in ability and in prerequisite skills. For the elementary fluid mechanics course, a third of the students said individualized instruction took less time than the lecture method (generally A and B level students), a third said it took about the same (B and C level students), and a third said it required more time (C and lower students). The lower level students were performing in this class at A and B levels.

Two obvious causes for low achievement are lack of motivation and prerequisite deficiencies (cumulative ignorance) allowed by the A-D grading system. It is reasonable to expect that a student who is required to pass each learning unit at a high level of performance (at his own pace) has one of the greatest of all motivators—high level success in those units he has completed. Furthermore, as his prerequisite deficiencies are overcome, he will no longer have this serious handicap. I am convinced that motivation and accumulated ignorance are the most prevalent causes of low achievement. *If the problems of motivation and prerequisite skills can be overcome—and individualized instruction offers far better answers to these problems than the lecture method has—then many of the so-called "low achievers" will achieve at significantly higher levels.*

3. *Using media dehumanizes instruction.* Individualized instruction requires the effective use of media,

but use of media in turn releases the instructor to help in diagnosing and solving individual learning problems. Thus, media humanize instruction. In my elementary fluid mechanics course, I used one class period for small group discussions and the remainder for testing and individual consultation. I came to know the individual student and his learning problems better by far than ever before in 15 years of teaching by the lecture method.

4. *What about the student who doesn't want to do A or B work in a course?* This question is significant for students who are taking survey or nonmajor courses. The answer lies in the term "relevance." A student majoring in the subject area of the course might have different terminal objectives than the non-major, perhaps even different amounts of credit, and individualized instruction readily permits this difference. The terminal objectives for nonmajors could be mutually agreed upon by instructors in the student's major field and those teaching the course. Those objectives considered to be of value to the student's education (relevant) would have to be passed at the mastery level of performance by every student of that category. Then, *the compromise is on time and not on learning.*

For students majoring in the subject area of the course, the desirability of doing high level work is obvious. The instructors teaching the course, in consultation with prerequisite and postrequisite course instructors, should set up terminal behavioral objectives for these students. These objectives should be the fundamental concepts of the course. The student who learns the fundamentals thoroughly will have great professional advantage over the student who learns "everything in the book," but poorly. When the terminal objectives are specified, each student should achieve them and time, not learning, should be the variable. The ultimate kindness to students is to require sufficiently high standards (mastery levels) of performance during their four years in the university so that they are best able to enjoy their 40 years of fruitful, successful, and satisfying professional life. *Every time a teacher compromises on learning by allowing mediocre performance and cumulative ignorance, he does a disservice to his students.*

5. *If students are told what to learn (terminal objectives), that is all they will learn.* Actually, this is one of the principal advantages of individualized instruction. When a student is told exactly what he is expected to learn and that he must pass a test on that item at a high level of performance, he will learn it. A large number of objectives based on the real fundamentals of the course may be necessary to cover the course. Three questions should be asked about each objective: (1) Why do I want the student to learn this? (2) Once he has learned it, what will he do with it? and (3) Once learned, how long should he retain it?

Master teachers have always stressed the fundamental concepts at the expense of the trivial, but in individualized instruction the student is forced to focus on these concepts by having a written list of them at the beginning of the course and being informed that he is to learn these at the mastery level. *With real*

understanding of the fundamentals, he will be better equipped to apply basic principles to the solution of new problems.

6. *If all students get A's and B's, the present grading system will be meaningless.* When a prospective employer looks over a transcript and sees that it took a student 2½ years to get a degree, all at high standards of performance, and that it took another student 6 years to do the same, he will have a far better indication of student ability than the present A to F grading system. Most professional work places quality practice far above constant time.

7. *Student reaction to individualized instruction as compared to the lecture method.* Students favor individualized instruction. A questionnaire asking for anonymous student reaction to the fluid mechanics course posed 21 statements, each to be rated on a comparison scale of 1, 2, 3, 4 and 5. (A rating of 5 indicated that individualized instruction was much superior to the lecture method, 1 indicated that the lecture method was much superior, and 3 indicated that the student considered both methods about equivalent.) The overall average response was 4.05, which indicated that students considered the self-paced instruction to be superior. The average rating by 33 students for part of these statements was as follows:

Development of desire to investigate subject beyond course requirements—3.46

Efficient use of student's time—3.85

Development of genuine interest in subject—3.89

Enjoyment of the learning experience—3.98

Accurate measurement of material learned—4.05

Personal challenge—4.09

Creation of original notions, ideas, and independent thinking—4.12

Understanding of important fundamental concepts and principles—4.12

Personal satisfaction in completing the course—4.26

Level of achievement in subjects covered—4.43

Preparation for professional life after graduation—4.46

Learning of material thoroughly enough for long retention—4.57

On three other questions posed: 93% stated preference for taking courses by individualized instruction; 100% thought that they should take courses by this method; and 61% believed that all their courses should be taught this way. The C student operating at a high achievement level in this course felt that he simply could not handle a full academic load at this level of work in a fixed-time (quarter) system.

8. *There are serious problems when this system is used in the context of a quarter or semester system.* Since time is the variable, an *Incomplete* grade is necessary for students who have not completed the terminal objectives of the course by the end of the quarter. This would require a change of the grade policy of almost all universities, and certain safeguards must be provided:

1. The instructor initiates the *Incomplete* grade for students who have not completed the course. He outlines precisely what the student has completed and what he has yet to finish.

2. *Incomplete* grades reduce the load of the student by one-half the credit of the incomplete course until the course requirements are finished. With 32 hours of *Incomplete*, a student can no longer sign up for new courses. Students must pay fees as for regular loads.

3. After one year, *Incomplete* grades are lined through on the student's transcript, and he must re-enter at the beginning of the course.

Such safeguards are not necessary if academic time is not in fixed units, such as quarters or semesters. Fixed-time periods are desirable for fiscal purposes, but academically it would be desirable to allow students to move at their own pace without fixed time. Thus, if a student completes a course early, he can go on to the next course immediately and the slower student can go beyond the average time.

9. *If students can move at their own pace, what will happen to the pace?* I am strongly of the opinion that when students look back on high-level achievement and when accumulated ignorance problems are largely removed, they will make substantial moves up the achievement scale. They will then finish in less time or in the same amount of time, but at much higher learning levels. Gifted students will move through at considerably less time than presently required, and many will finish school in three years or less.

10. *Individualized instruction may work for small classes, but it is impractical for large ones.* If a hierarchy of learning tasks and experiences is studied by the teacher, he can see where his contribution is most important and where it is less. Most of the less important items can be relegated to media, teaching assistants, etc. Ideally, a team approach involving specialists in subject matter, learning, media, educational methods, etc., would best meet the challenge of designing individualized study for a large class (or for any size of class). Both Dr. S. N. Postlethwait of Purdue University and Dr. E. B. Kurtz of Kansas State Teachers College have conducted courses using individualized instruction involving more than 1000 students.

11. *Behavioral systems design of a course for individualized instruction can be done in other fields, but not in engineering.* Actually, educators in a wide spectrum of educational levels and subject matter are trying individualized instruction, and their efforts have convinced them that it can be done. The major problems they face are not its impossibility, but rather its introduction into an environment which is hostile to the extent of the iron-clad constant time. If there is any possibility of individualized instruction being the

ideal, is there not some obligation for engineering educators to give it serious thought and effort?

Recommendations

Individualized instruction holds real promise to answer most of the questions unanswered by the lecture method. With it, learning can become the constant and time the variable. With it, there is no need to compromise on learning, and low level achievement can be essentially eliminated. With it, designed failures no longer exist, and yet considerably higher educational standards can be maintained than at present. It holds promise for increasing the motivation and performance levels of the majority of students. With it, the teacher's role changes from a presenter of content to a diagnostician of learning problems and designer of learning experiences to overcome these problems for each student. He does what only he can do and what proves to be the most valuable contribution he can make to the learning process. With it, teachers can approach the ideal of *developing each individual student to his ultimate potential*.

The most serious question about individualized instruction is whether it is practical. I am convinced from my experience that it is practical—especially in light of results obtained. The major purpose of this article is to encourage fellow engineering educators to take leadership in trying and proving its limits of practicality, its strengths and limitations. If our efforts can help to improve education markedly, we will affect the lives of millions of learners at all levels of education. The impact on mankind would be tremendous and would compare with the greatest engineering achievements.

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