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ABSTRACT

The activites of the Consulting Group on Instructional Design and some faculty members for whom it has made a difference are discussed. Through faculty seminars, consultation, and cooperative efforts with faculty to develop instructional programs utilizing new strategies and technologies, the Consulting Group tries to improve the effectiveness of the teaching and learning processes at the university. Most of the projects under active development in collaboration with the Consulting Group are clustered into four curricular areas: medicine, art history, law, and second language learning. Selected developments in each of these areas are described. (LBH)

comment

Consulting Group helps faculty bring systematic approach to instructional design efforts

The Consulting Group on Instructional Design: its name doesn't trip off the tongue, but it should be at least familiar to University faculty members who seek to upgrade the effectiveness of their instructional efforts. Through faculty seminars, consultation, and cooperative efforts with faculty to develop instructional programs utilizing new strategies and technologies, the Consulting Group tries to "make a difference" in the effectiveness of the teaching and learning processes at the University. This issue of Comment *discusses activities of the Consulting Group and some faculty members for whom it has indeed made a difference.*

Effective instruction is objective of research-development projects

> "You are a pediatric intern in an intensive care unit of a university teaching hospital. It is 10:30 p.m. of a long day in which you have not had an opportunity to have dinner. A seven day old infant is admitted from Frozen Falls, Minnesota. . . ."

Reading this introduction from the viewing screen of a computer terminal at the Health Sciences Learning Resources Center at Diehl Hall, a medical student begins to work through a simulated clinical situation. With a few touches to the keyboard, the student requests information and tests to help in making a series of crucial decisions about the infant's treatment. Each decision brings new consequences and requires new choices. The infant will be saved or will die on the basis of how well the student is able to apply principles involved in managing the case. The program was developed by University pediatric cardiologist James Moller as a means of giving students practice in making patient management decisions.

This computer simulation is just one of many projects developed at the University through combined efforts of faculty from the subject-matter disciplines on the one hand, and research-oriented cognitive psychologists and instructional designers on the other. Providing stimulation, coordination, and a share of the expertise for such efforts is the Consulting Group on Instructional Design, an all-University service unit directed by Russell W. Burris.

Projects undertaken by faculty and the Consulting Group often incorporate new instructional techniques and technologies—such as computer-based instructional

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programs calling for student interaction, or slide-tape instructional units to be used independently at the student's own pace. They also make use of laboratory research into questions of learning, cognition, perception, comprehension, competence, and memory. At the same time, they afford a setting within which further research, both basic and applied, may be conducted.

The Consulting Group, affiliated with the Center for Educational Development since last year, was established in 1962 as the Center for the Study of Programmed Learning. Initially supported by the Hill Family Foundation and headed by Burris since its inception, the center was founded to serve as a locus for the study and development of programmed instruction within the educational offerings of the University. In 1969, it was also designated as the unit to study and develop the University's uses of computer-assisted instruction. Its recent name change reflects its current concern with more broadly defined questions of instructional design.

Consulting Group staff members include Burris, who is also a faculty member in educational psychology; faculty associates Paul Johnson of educational psychology and Paul Fox of psychology; Elaine Parent, a research fellow who works closely with faculty on several projects; computer programmers Keith Hazelton, Earl Schleske, and Wolfgang Rothen; LaVonne Molde, who coordinates administrative aspects of the Consulting Group's activities, and six research assistants.

The Consulting Group conducts applied research relating to specific projects. For more basic research into human learning processes, it draws upon the resources of the Human Learning Center, established in 1963 with funds from the National Science Foundation and National Institute for Child Health and Human Development. The two units

Instructional design based on key questions about teaching, learning

During the early weeks of the faculty seminar conducted two or three times yearly by the Consulting Group on Instructional Design, director Russell Burris lays a foundation for analysis of any teaching-learning situation. He identifies some basic elements of instructional design, raising pertinent questions:

Performance criteria: What does an individual "know" when we say he or she "knows?" What occurs in a person's performance upon which we make the judgment that he or she knows? What distinguishes that person's performance from that of the individual who does not know?

Learning sequence: In what sequence will the material be learned most effectively? How is the body of knowledge structured, and what does this suggest about optimum learning sequence?

Learning strategies: What must the learner do to learn what must be learned?

Instructional modes and media: How are the appropriate instructional techniques and technologies selected to best carry out the chosen learning strategies?

Motivation: How can various affective considerations optimize learning?

Individual differences: How are individual differences in learning relevant to effective learning situations? What kinds of different learning situations are needed to optimize learning among different individuals?

Using a favorite analogy, Burris also encourages seminar participants to conceptualize the learning process by thinking of each discipline as a language. The specific information to be learned may be likened to vocabulary, structure, and syntax, he suggests. Most important, however, and most difficult to teach, are the rules by which these elements are "manipulated" and "transformed" in processing information and solving problems, i.e., the "grammar" of the discipline.

Drawing an example from a discipline with which the Consulting Group has worked extensively, he observed that an art historian may have little difficulty recognizing another expert in the field, but is likely to find it hard to describe what that expert "knows," i.e., what rules he or she follows in carrying out the tasks performed as an expert. Teachers of art history may find it relatively easy to set forth the "vocabulary" of the discipline, to impart specific bits of information, but much harder to describe or define the rules by which that information is to be transformed and manipulated. Consequently, it is difficult to devise learning problems through which the student may begin to internalize those rules.

work jointly on many projects; they share some staff and occupy offices together at 205 Elliott Hall on the Twin Cities campus.

Seminar provides framework for analysis of problems

A faculty member's contact with the Consulting Group usually begins with a ten-week seminar offered two or three times each year. Notices are sent to all faculty members, and attendance is generally between ten and twenty. Often, those attending have been encouraged to do so by colleagues who have taken part previously.

During the first few weeks of the seminar, Burris discusses basic elements of instructional design. In latter weeks, he asks participants to use this information as a frame of reference to define a particular teaching-learning problem of their own experience and to work out a pilot project for its solution. Participants receive individual assistance in identifying the problem and developing the project.

Such a project may entail any of several activities: restructuring course content; developing printed course materials which make use of new instructional strategies; employing slides, tapes, computer, or other technology; or taking a new approach to evaluating student performance based on redefinition of the skills to be imparted in a course. Many projects are modestly scaled and easily implemented by the individual instructor. Others provide a setting for continuing development efforts in conjunction with the Consulting Group.

Educators, researchers cooperate in instructional development

A long-term collaborative effort typically gets underway with a series of meetings among the faculty member originating the proposal and those individuals from the discipline, the Consulting Group, and the Human Learning Center who will participate. These meetings serve as a forum for clarifying objectives and further developing the proposal. Staff members of the Measurement Services Center may participate in planning evaluation aspects of the project, and Management Planning and Information Services staff may help determine cost and feasibility.

The Consulting Group may draw upon limited financial resources of its own to help usher a project into being. Funding for full-scale development work is sought through proposals developed jointly by the academic unit and the Consulting Group. Most such support comes from University sources such as the Educational Development Program; other funds are sought externally.

Burris noted that the psychologist-researchers, instructional designers, evaluation specialists, and discipline-oriented people involved in any given project each work within their own areas of interest, drawing upon the expertise of the others.

As an example, Burris cited the development of television- and computer-assisted instruction in the German language. The project was originated by Cecil Wood, professor of German, who now also holds an adjunct appointment in the Human Learning Center. A linguist, Wood is primarily concerned with pedagogical issues involved in teaching and learning German. In developing his instructional programs, he draws upon the psychologists' expertise in learning theory. Meanwhile, the psychologist-researchers working on the project are interested in questions of second-language learning *per se*, each from a specific domain within psychology. For application of their theories, they draw upon Wood's knowledge of the problems of teaching and learning the target language. Among current research interests are the effectiveness of the various components of a media-aided language course (measured both by student performance and student attitude) and effective evaluation of second-language learning.

Most of the projects under active development in collaboration with the Consulting Group may be clustered into four curricular areas:

Medicine, with computer-based instructional simulations being used in hematology, ophthalmology, family practice, and pediatric cardiology, and similar development underway in anatomy and psychiatry;

Art history, in which self-paced slide-tape instructional units are being used or developed to teach survey courses in ancient, medieval, and Asian art history;

Law, with a computer-based simulation being used in a civil procedure course, and other simulations being developed by law faculty from a number of institutions and the Consulting Group in a project funded by the Ford Foundation-sponsored Council on Legal Education for Professional Responsibility; and

Second language learning, initiated with Cecil Wood's development of computer-assisted instruction in German and now expanded to Dutch, Swedish, Norwegian, and ancient Greek.

The remainder of this issue will focus on selected developments in each of these areas.

Medicine: computer-simulated case helps teach problem-solving approach

As James Moller has gone about developing computer problems for his students in pediatric cardiology, he and the Consulting Group on Instructional Design have been interested in a key question: by what process do medical students learn the problem-solving approach? How do they learn, for example, to make the decisions involved in managing a patient's care?

The traditional text-and-lecture approach, Moller said, does not adequately teach problem-solving. A medical student may be quite capable of associating a given set of symptoms with a given disorder, for example, but unprepared to identify those symptoms on the basis of a patient's vague complaints. Moller concluded that these and other elements could be built into a computer-based clinical simulation. The student, in the role of a doctor faced with a series of alternatives in managing a case, would experience valuable decision-making activity before getting into an actual clinical setting.

Moller developed his first simulation—that of an infant brought from a rural community to a university teaching hospital on advice of the family physician, described on page one of this issue—earlier this year. He has used it with fourth-year medical students as well as interns and residents. He hopes to develop additional simulations, not, he explains, to expose students to every type of clinical situation, but to provide experience in thinking through important problems.

The infant-care case has been programmed to allow the computer to provide important information to both student and instructor. Items are numerically weighted, so the student's performance may be scored in terms of correctness and other factors, such as efficiency. (Future simulations may even incorporate such realistic elements as a clock ticking away the minutes.) The student may compare this score with the average score of practicing physicians who have worked the problem. For his part, Moller can obtain a printout of student responses, allowing him to discover elements which are particularly troublesome to students.

In addition to the clinical simulation, Moller and his associates have put the computer to other instructional uses. A program developed by medical student George Biltz uses a question/answer format to teach and review basic information. When the student makes an error, the computer gives correct factual information and prescribes review in specific areas. Moller believes more review programs are needed.

A diagnostic program, developed by Leonard Blieden, a cardiology fellow, teaches students to make fine discriminations in interpreting medical evidence. Information on a six-year-old patient is presented to students, much of it by means of audio tapes (heart sounds) or slides (of EKG charts, x-rays, or photographs of the patient). Students are asked questions leading to diagnosis, and their answers receive immediate reinforcement or correction. For example, if a student misinterprets a particular heart sound the computer will indicate not only the correct interpretation of the sound heard, but where to go on the tape to hear an actual example of what the student incorrectly thought he or she heard.

A fourth type of program was developed by David Swanson, graduate student in psychology, and Paul Johnson, Consulting Group faculty associate, to provide a simple format for students to use in programming cases of their own for the computer file. Once a case is programmed, a student user can receive introductory information about a patient and, on request, information about medical history, physical examination, and laboratory data. The user diagnoses the patient's problem and selects management alternatives. Responses can be scored and compared to an optimum score.

Support for development of these programs has come from three sources: the Dwan Family Fund, the Educational Development Program, and resources of the Consulting Group. While student response to Moller's programs has been favorable, he plans to place more emphasis in the coming year on documenting the learning that takes place.

Moller became interested in the computer as an instructional tool primarily because of the work in hematology of a former University colleague, James McArthur, now at the University of Washington, Seattle. Other health sciences faculty also are developing and using computer programs in conjunction with the Consulting Group staff, among them Robert Letson in ophthalmology, Rafi Younoszai and Donald Robertson in anatomy, Joseph Westermeyer in psychiatry, and Stuart Thorson in family practice. Although they are pursuing independent projects, they meet periodically as a group to discuss matters of common interest.

Moller feels that the computer can add to medical education a dimension not otherwise possible, but said it does not reduce either the teaching load or the amount of time spent by an instructor with students. While the computer has some unique capabilities, he cautions against believing that it can solve all teaching-learning problems. Rather, he believes it should be con-

sidered just one of many innovative teaching methods which might be useful in a given situation. Keys to successful use of the computer in instruction, Moller suggests, are making sure it is being used appropriately, and taking time to develop good programs.

Moller and Burris exhibited the four prototype programs in pediatric cardiology at a recent medical education conference in New York, and said other medical schools indicated interest in developing similar programs. There are also potential commercial uses—for example, a manufacturer of electronic pacemakers is considering the method to educate doctors to diagnose problems encountered by patients using the devices. Computer programs might also be an attractive approach to continuing post-graduate education for physicians, allowing more interaction than the standard methods of reading or attending lectures.

Art history: self-paced units allow increased faculty-student contact

Students in Sheila McNally's survey course in ancient art history learn most of the course's content by listening to audio tapes and viewing sets of slides on their own time at the Learning Resources Center in Walter Library. While the approach may sound coldly impersonal, her reason for adopting it was just the opposite—she wanted to overcome the anonymity of the traditional lecture system. She says it is working.

McNally is one of five art history faculty members currently developing forms of self-paced instruction for their courses. The others are Alison Benjamin-Stones and John Steyaert in medieval art history, and Robert Poor and Frederick Asher in Asian art history.

Her interest in finding an alternative to the lecture method began several years ago with an incident she recalls vividly. "I was looking out from the stage of the auditorium where I lectured, and I noticed a young woman smiling up at me. I realized it had been a long time since I had seen anyone out there as a real person." She resolved to find a way to break down the formal structure of the lecture course and enable herself to establish more contact with her students.

Her search led to a long-term association with the Consulting Group and to the development and use of some two dozen slide-tape instructional units available to students for study at their own pace. These units are the primary instructional medium for the course. Each consists of an audio tape and coordinated set of slides to which the tape makes reference. Students obtain these materials from the desk at the Learning Resources Center in Walter Library and play them on machines in the center. They can replay any section as often as they choose. Written exercises accompany the units.

Five exams, or "evaluations," are to be taken during the quarter. Ideally, these are taken whenever the student is ready; realistically, some students must be spurred by means of a "strongly suggested" schedule. McNally and a teaching assistant spend designated hours at the Learning Resources Center (six or seven hours a week each in normal times, up to twenty each in end-of-quarter rush periods). They dispense copies of the evaluations to students wishing to take them, and then discuss with students their performance on the evaluation and in the course.

Students may retake each evaluation without penalty until satisfied with their achievement. McNally says this option enables them to reach a high level of performance, as reflected in the grades they are earning.

Although she has now offered the course using self-paced instructional units four times, McNally says it is still experimental. Some of the materials will again be revised this summer, and she has not entirely settled on an overall course format. Wanting students to meet together regularly rather than working only in isolation, she has tried out various combinations of lecture meetings and smaller sectional units. With students learning material at different paces, she has found lectures of little use. Sectional meetings, on the other hand, provide an opportunity to assign exercises, many of them to be carried out in small groups.

McNally sees such groups as one potential way to encourage student interaction. She would also like to find other ways to restore some of the informality lost when the rapid growth of the class (from 60 students a few years ago to 230 last quarter) necessitated a move of the slide-tape equipment from a lounge-style working area to the more formal setting at the Learning Resources Center.

During the past few years, McNally and the Consulting Group staff have experimented with pretests, questionnaires, student course evaluations, records of usage of the slide-tape units, and other sources of data about the effectiveness of her course. Their experience is beginning to pay off in terms of information both about their data collection methods and about such questions as how students pace themselves through the course,

how to identify early in the quarter those who will have trouble finishing, and what aspects of the course are most troublesome for students. One important consideration is getting sufficient information without overburdening students with forms and questionnaires.

McNally said the high level of student performance and positive reaction to the course have already shown it to be successful. Students have expressed their enthusiasm for the opportunity to learn at their own pace and to receive individual attention. At the same time, they have been critical of mechanical problems, such as long waits for interviews with McNally or the teaching assistant in the rush at the end of the quarter, or malfunctioning machinery during the same rush.

McNally herself finds the approach both "exhausting" because of the large amount of time it requires and "extremely rewarding" because it allows her the opportunity she had sought to give individual attention to her students.

The five Art History department members working with self-paced instruction meet weekly with Consulting Group staff for discussion of theoretical and practical issues of individual and common concern. Some of their developmental work has been supported by University sources including the Educational Development Program and Council on Liberal Education Small Grants Program, and funds for equipment and slides have come from the U.S. Office of Education. A substantial recent grant from the National Endowment for the Humanities will support further development.

Law: computer-based problems supplement classroom discussion

Students in Roger Park's first-year civil procedure course at the University's law school develop their understanding of the rules of evidence by playing the role of a judge asked to rule on objections in a case played out by computer. Having read assigned text material, they are asked to apply such principles as relevancy, hearsay, and leading question to evidence presented in the simulated case. Each answer brings a brief explanation of why it is correct or incorrect; an incorrect answer also brings an invitation to try again. After a few incorrect tries, the student may request a hint. Overall performance can be scored and compared with an average.

Park developed the program last fall to give students in his large classes more individual attention and a more active learning experience than he could otherwise provide. Since the program is a supplement, he reasoned that even if experiments proved less effective than he hoped, students would still receive the necessary material through classroom teaching.

Both Park and his students have been pleased with the results. Ninety-one of the 102 students in the class responded to a questionnaire. All but five thought the computer program was an effective resource in learning basic evidence. Eight-two felt it was an enjoyable way to supplement the civil procedure course. Eighty said problems and questions were answered by doing the exercise.

Students came to class with many more questions as a result of their experience with the simulation, Park said, and a computer printout of questions most often missed indicated some difficult points he may not have detected from normal classroom interaction.

The computer cannot and should not replace class discussion, Park said. However, it is a useful supplement, particularly in large classes, to the Socratic method used in most law school courses in which students are expected to apply underlying principles they have learned from their reading. It is generally assumed that students not participating actively are nevertheless taking part vicariously in the reasoning process. However, Park believes the method is less effective in very large classes. The computer counters this by presenting each student with at least one occasion when it is necessary to participate actively in the problem-solving process. The most serious potential problem, he said, may be lack of accessibility of computer terminals if large numbers of students are assigned large amounts of work.

This summer, Park will work under grants from the Educational Development Program and the Council on Legal Education for Professional Responsibility (CLEPR) to develop additional problems, most of them allowing the student to play the role of lawyer or judge. He hopes gradually to increase the complexity of his programs.

Park's program was demonstrated at a recent CLEPR board meeting in Florida. A Ford Foundation-supported agency, CLEPR is concerned with upgrading components of legal education affecting the development of professional responsibility. In a project funded by CLEPR, Burris is working with law faculty from other institutions to develop computer simulations involving torts and insurance law. Among these is a sophisticated simulation developed by Robert Keeton, formerly of the University's law school and now of Harvard. Keeton's program involves pretrial, trial, and post-

trial procedure and requires some twelve hours to work. Questions of fact, tactics, and ethics all are included. Where possible, items are scored. On ethical questions, the student is given a profile of responses of law professors, practicing attorneys, and judges who have worked the problem. CLEPR and other groups concerned with legal education are interested in use of computer programs both as a form of pre-clinical legal education and for continuing education for attorneys.

Second-language learning: computer drills help teach grammar

A student learning a second language must continually build upon things already learned; each step depends upon the proper foundation. Thus it is important not only to present material in proper sequence but to teach it effectively at every step. This concern has prompted German department faculty member Cecil Wood to experiment over the years with many modes of instruction for his beginning German course. He continues to develop computer programs, television and audio tapes, and textual materials, and to experiment with their use in various combinations and formats.

Wood has developed a series of computer-based instructional drills which give practice in manipulating the language, and thus help students internalize the rules of grammar. Computer printouts give Wood data about individual as well as class performance, data which can be used both in helping students learn the material and in developing further programs.

Television and audio tapes expose students to the spoken language, presenting vocabulary, grammar, and cultural material. A textbook written by Wood some ten years ago, and revised several times since, embodies results of years of experimentation with sequencing and structuring material to optimize learning. These instructional aids, supplemented by other written materials, free the instructor from teaching basic material in favor of more interaction in which students use what they have learned.

Students may take the 15-credit, three-course sequence in beginning German using a great deal, some, or none at all of Wood's television and computer programs. Some sections of the course feature a traditional classroom approach, with an instructor giving five lectures each week. In other sections, Wood's television tapes substitute for two of the lectures, and computer-assisted instruction supplements classroom learning to varying degrees. In addition, some students are taking the course on a contract basis, one credit at a time, with access to all instructional materials as well as tutorial assistance.

A cost analysis of these approaches conducted last year by Ronald Zillgitt of the University's Management Planning and Information Services showed that use of computer-assisted instruction and closed-circuit television can help reduce the cost of instruction. The study projected costs of various modes of instruction per student credit hour.

Cost of a traditional lecture approach varies according to the instructor's salary and workload. For a teaching associate earning $4104 annually (a rank chosen arbitrarily for the study), giving five lectures per week to three sections of 30 students each year (currently a standard workload in the German department) the cost is $9.12 per student credit hour.

Production and viewing costs of Wood's television tapes, based on a projected five-year life span, average out to $3.21 per student credit hour. When the tapes are used as part of the classroom approach, they replace two of the five lectures each week and allow the instructor to teach 135 students instead of 90 each year. Cost of classroom instruction is reduced from $9.12 to $8.68 per student credit hour.

Computer-assisted instruction, which requires purchasing equipment and leasing access time, currently costs $1.92 per student credit hour for beginning German students. Its use in combination with lectures and television enables the instructor to teach 150 students each year, at a total cost of $5.69 per student credit hour.

The television and computer programs are also used by students taking the course on a contract basis; one instructor can assist 180 students a year by this method. Cost is being studied and is expected to be comparable to the other methods.

The study points out that in a long-range trend, manpower costs are rising while computer costs, because of faster machines and lower manufacturing costs, are dropping. In addition, use of technological aids such as television and the computer generally allow the instructor either to teach greater numbers of students (further reducing unit cost) or to perform other activities, such as giving more individual attention to students.

Wood and Burris say performance of students on exams has demonstrated the effectiveness of both television and computer-assisted instruction, particularly in terms of students' ability to handle grammar. However, they are dissatisfied with the adequacy of exams to measure second-language learning. Research and development in this area

are being conducted by Wood, Gerhard Clausing of the German department, and Dale Lange of secondary education.

Wood's computer programs have been used in teaching introductory German at the University of Minnesota, Duluth. They also are the models for programs being introduced this year by Richard Auld in Swedish; Solveig Zempel in Norwegian; Ray Wakefield in Dutch; and Gerald Erickson, Michael Kunin, and Walter Nichipor in ancient Greek. Development of materials in still other languages is underway for use next year. The German programs also are accessible to high schools and colleges of Minnesota and beyond through the MERITSS computer network.

Much of the development of second-language learning programs at the University has been done using the Computer-Assisted Language Learning System (CALLS), developed by the Consulting Group for use with the language equipment at the Learning Resources Center in Walter Library. CALLS (as well as, eventually, other specialized systems) is part of the Minnesota Instructional Language, developed by the Consulting Group for use by authors of instructional programs.

Wood considers the computer not only effective but a "kind and patient" teaching aid. "It allows students to make their mistakes in private. It lets them learn as slowly and clumsily as they need to, or move ahead quickly when they are able." However, he acknowledged that many students want and need more personal attention than he and his teaching assistants have had time to give. He spends mornings at the Learning Resources Center in Walter Library where students may talk with him, and has built other personal contact situations into his classes. But he said more such contact is needed, and ways must be found to provide the different styles of guidance needed by different students, particularly when they are asked to assume a high degree of responsibility for their own learning (as are the students taking his course, on a contract basis). These questions will command a major share of his attention as he continues experimentation with his course.

Effective instruction traced to instructor, not machine

Although there are critics of computer use in the classroom, Burris does not see his work as leading to dehumanization of the learning process. "Actually, the machine may be more humane than the teacher in some situations," he said. "In repetitive drills, it has more patience than many teachers could summon. It doesn't get tired, or sarcastic. Of course, it can't get creative, either.

"The computer isn't taking over for the teacher," he said, "but it can take over the routine tasks, and perform them efficiently and effectively." In fact, data gathered on Consulting Group projects clearly show that the computer used in this way can effectively teach people, he said. Yet it is not the machine itself which is primarily responsible for the learning which takes place.

Some projects undertaken by faculty members in conjunction with the Consulting Group place heavy emphasis on the computer, others rely importantly on visuals and magnetic tape; many are best carried out through the printed page. Burris pointed out that each begins with a systematic analysis of subject matter and objectives, and he believes it is this systematic approach, rather than the medium used, which is most important in bringing about an effective solution. "It is not the computer or the tape or the piece of paper which makes a project effective, it is the teacher," he said. "Without effective development of instructional design, the machine would be useless."

comment

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