The educational value of this technology is its capacity to produce carefully constructed resources more efficiently than otherwise.

3) The system can provide immediate feedback from tests, objectivity, standards consistency, easy maintenace of the records of student progress, and increased test security.

4) The system can be adapted to almost any discipline or subject of study. Samples are available for examination on request.

5) Other programs can be developed and integrated with Quesgen which will enable students in the future to requisition tests individually, write such tests, and have them evaluated immediately. The result of the test or tests would be stored in the computer files in order to keep a record of these students' progress and accomplishment. The ultimate goal of making it possible for all persons to proceed toward accreditation at their own speed in accordance with their own needs and exigencies, is within reach.

6) With Quesgen, it is quite possible to provide tests on demand without any great inconvenience to either the teacher or the administration. You may allow students to write as many tests as they wish and to give them credit for their achievement regardless ofhowmanytestshe/she may havewritten.

Upgrading need not be withdrawn as long as the student wishes to make the effort. It would be logistically impossible to provide this accommodation for students if it were not for the fact that the system substantially reduces the drudgery of creating questions, and tests, and of marking them.

7) Because of the potential number of variations, there should be no concern about students keeping their copies of the tests; as was indicated in the preface, the number approaches infinity. In fact, students should be encouraged to keep their copies as part of their notes for study and review purposes.

8) The ease with which tests are created and the consistency of their taxonomy also make it possible to have a large number of students write a test in the same room, but with a number of variations which will make it futile for students to signal answers back and forth. Invigilation is more effective and less expensive.

9) Most teachers dislike the role of judging who shall pass and who shall fail, both because they are not so confident of evaluation methods and techniques that they believe they are always accurate and fair; and also because they prefer to leave an option open to students to improve their grades by their own efforts. By making the opportunity for rewrites, or upgrading tests, available on demand, the student becomes much more the author of his own fate. This is as it should be, and the option for upgrading should never be withdrawn as long as a student wishes to make the effort. It is much easier to achieve this ideal when computer testing is available.

10) By using case-studies as part of a workbook or study guide, the student can be directed to apply the knowledge gained in the lessons. Questions can be based on the case-studies in the same increasingly comprehensive and complex way as for the lessons or units of study themselves.

Flow-Charts, diagrams, schematics, illustrations of all kinds, and even complicated mathematical problems and formulae can be presented in the same way.

11) Most people find it difficult to read AND ABSORB text material or technical manuals unless they are highly motivated to do so. A well designed study-guide requires a student to look for the answers to specific problems in their learning resources. Their ability to concentrate on the text material is substantially enhanced with this learning aid.

12) The improvement of self-directed learning resources leads to improvements in facilities for disadvantaged or handicapped persons who may be confined to their homes or are otherwise, limited as to their mobility. Persons whose access to learning is restricted by the remoteness of their location, can be brought into direct contact with these resources with relatively small cost. If a telephone is available, they need only a modem and an inexpensive word processing setup in order to access what can be a vast educational facility.

13) Integrated learning and testing by which related subjects are tied in to the main course of study, is more easily accomplished when a study-guide and tests are generated by computer. For example, if the primary objective of a course is an understanding of the principles of marketing, the secondary objectives

would include an understanding of the influences created by laws, economic conditions, sociological conditions and psychological factors, to mention only a few prominent ones. You may create study-guides which draw questions from all of these areas of study and weight the degree of imput as you direct.

Study guides and case-studies can be tailored to individual or small group needs, and the mechanisms now available make this economically feasible.

14) Team-teaching can be significantly enhanced by integrating each specialized presentation to the others as above, and by designing case-studies which expand to include problems based on each specialized unit of study as it is presented.

15) "Table-top" publishing can create resource material which may also be accessed by modem and reproduced as needed by the user. Learning resources can, thereby, be made available using a "shopper's mart" concept as a marketing device. A catalogue of resources can be made available through the computer, and the user may then select the combinations of units of study which meet his/her individualized needs as set out in course outlines. They can be reproduced under licensing arrangements and printed locally in quantities as may be required.

16) These resources can be made available from central sources to any user, whether that be a person, corporation, educational institu-tion, certifying body, or government agency, by using the technology as described above.

17) In this era of rapidly expanding technology and automation, the need for retraining becomes inevitable. In many cases the candi-date has achieved advanced standing in the school of hard knocks, but has very little formal qualification. In order to assess a candidate's entry level, the availability of computerized testing on demand has obvious advantages. The individual can be provided with study-guides and resource material, and when he/she wishes to write a test to determine the level that has been reached, the opportunity is readilyavailable, as are repeat attempts.

The same can be said about persons who may need to acquire a prerequisite to qualify for a program of studies.

18) For the protection of society, governments are finding it to be increasingly necessary to regulate service industry by requiring persons who take it appear that they have the knowledge and skills to advise or represent people, to prove their qualifications by meeting certain standards. A case in point is a recent bill presented to the Ontario legislature to qualify and regulate "paralegals." Some persons have been practising as such for decades. Computerized testing. as described in this manual, can go a long way toward determining existing standards by which qualifying standards may be established. Having made this deter-mination, the qualifying agency can then adjust the standards to suit their purposes.

Refresher courses and upgrading facilities are much more accessible to persons in all parts of the territorial jurisdiction of the licensing agency.

19) On completion of a test by students, it may be marked by computer. The results, and a complete analysis, can be made available within the hour.

20) You may develop and use your own data bases with your own coding.

CODING

The parameters for coding are built into Quesgen. It provides for 10 books, with 99 chapters in each book, with 99 units in each chapter.

"Books", "Chapter", and "Unit" are simply nomenclature, and you may put any name on your classifications that you wish.

If you use "chapter" in its ordinary context, Quesgen allows you 99 classifications of statements that you may wish to create with respect to the chapter. It is important to remember that you are not restricted to classifications that are based on the understanding of theory and there are many alternatives as described above.

UTILIZATION OF YOUR DATABASE

a) Practice and Pretests

Most students are not familiar with the type of tests that are generated by "Quesgen", nor are they familiar with the diagnostic value and implications of the "T.E.S.S." scoring system, described on page 9. Once your data base is in place, it takes less than a minute to generate a practice test and about 30 minutes to have your students write it. A good practice is to allow the students to do so anonymously by adopting pseudonyms which enable them to ascertain their individual results without identifying themselves.

This can serve two useful purposes; (i) When you get back the analysis of the test result from "T.E.S.S.", you can explain its interpretation of the data and its applications to the class so they may understand the objectivity of the testing, and its diagnostic value. They will appreciate then that the testing is an integral part of learning. (ii) It will also enable you to assess the class's level of understanding of the subject.

b) Mini-Tests

"Quesgen" and "T.E.S.S." make frequent testing and marking simple and almost effortless.

c) Study-Guides

A well designed study-guide will enable your students to read and absorb the instructional material. This conclusion is based on the premise that a person's ability to concentrate on texts or technical manuals will be greatly enhanced if he/she is looking for the answers to specific problems.

In short, a teacher can design a study-guide according to his own specifications that will best meet the needs of a group of students for whom he/she is responsible, and vary them for other groups.

Study-guides may be created from a combination of any or all of the statement files that YOU create. And most importantly, these "tailor-made" study-guides can be created in far less time than it takes to prepare an ordinary 4 or 5 page course outline.

PROGRAMMED SELF-DIRECTED LEARNING PACKAGES

The essential differences between learning packages and ordinary study-guides is that the "Packages" might include the following:

(i) A summary of the text material or the text itself.
(ii) The test items and exercises as in the study-guides.
(iii) The solutions and a short explanation of the answers.

All of the foregoing can be transmitted electronically to learning centres in remote locations or directly to students who may happen to be handicapped, IF ON-LINE EQUIPMENT IS AVAILABLE.

It takes a telephone, a modem and a micro computer with printer. But clearly, the data base must be researched, developed and field tested.

TAXONOMY

1) The statements in the questions themselves may be simple, for example, 2 + 2 = 4; or complex, for example, E = MC

2) The construction of the questions may be simple, i.e., True/False or complex, i.e., with three or more distractors.

3) The subject matter of the questions may be simple, i.e., drawn from one unit of study, or complex, i.e., drawn from two or more units of study.

4) The questions may be created with three or more distractors; from two or more units of study; and from statements that are simple or complex, ... as the user may direct.

5) The knowledge acquired may be applied by employing case-studies, which in themselves may be classified as in 1, 2, 3, and 4.

6) The following types of learning outcomes may be programmed into the data base:

1. KNOWLEDGE
   - 1.1 Terminology
   - 1.2 Specific facts
   - 1.3 Concepts and principles
   - 1.4 Methods and procedures

2. UNDERSTANDING
   - 2.1 Concepts and principles
   - 2.2 Methods and procedures
   - 2.3 Written material, graphs, maps, and numerical data
   - 2.4 Problem situations

3. APPLICATION
   - 3.1 Factual information
   - 3.2 Concepts and principles
   - 3.3 Methods and procedures
   - 3.4 Problem-solving skills

4. THINKING AND READING SKILLS
   - 4.1 Critical thinking
   - 4.2 Scientific thinking
   - 4.3 Logic and Deductive Reasoning

5. GENERAL SKILLS
   - 5.1 Laboratory skills
   - 5.2 Performance skills
   - 5.3 Communication skills
   - 5.4 Computational skills
   - 5.5 Social skills

You may become the composer/arranger of learning resources.

TEST REQUISITION

The following is a hypothetical requisition for a test which illustrates the criteria that you may input into the design of a test.

Title - Laws 103
Date - 88-01-29
Instructor - Socrates
Number of questions required (40)

Specify the units of study

Book	Chapter	Unit	
1	1	1,2 & 3	
1	2	1 & 2	(you may specify up to 10)
1	3	1	

Do you wish to emphasize any particular units? Yes or No Yes

If so specify the unit(s) and give an approximation of what percentage of the statements in the test that you wish to draw from that/those units.

B1-C1- Unit 1 - 20%
Unit 2 - 20%
Unit 3 - 20%

B1-C2- Unit 1 - 15%
Unit 2 - 15%

B1-C3- Unit 1 - 10%

100%

Specify the Difficulty Level(s) required
(the range is 1 to 10 but these may be compounded as the requisitioner chooses)

Level	Number of Questions
1	10
3	15
4	09
5	03
6	03
Total	40

Quesgen will generate your test based on these criteria in less than one minute.

T.E.S.S. - THE TEST SCORING SYSTEM

T.E.S.S. will provide . . .

A - Student Grades

The printout provides this data in descending order, ascending order, alphabetical order, or in numerical order if the student numbers are used to identify the candidates.

INDIVIDUAL STUDENT INFORMATION--The printout shows a "line score" for each student indicating the answer that was given on every question. If the right answer was given the printout shows a dot; if the wrong answer was given the printout shows the letter which was given as the answer; if no answer was given there will be a dash; and if a multi-answer or invalid answer was given there will be a question mark.

B - Statistical Data

This includes a statement of the high, the low, the median, and the mean mark. In addition, the printout shows the distribution of the marks from 0 - 100 by specifying how many score in the 90's, 80's, 70's, etc.

C - Questions Information

The printout shows the question number, the answer as inputted to the computer, the number of students who chose answer A, B, C, D, or E, and how many gave no answer or an invalid answer. An invalid answer may be a double answer where the student did not cleanly erase a choice and made a second choice, as a result of which the computer picks up both.

The program will accept two or more choices as an answer, in which case a student who only gives one choice would be marked wrong.

D - Questions Difficulty Level

The computer gauges the difficulty level of each of the questions on the basis of the success or failure of the class in answering it. A range is shown from 100 for the top or easiest questions, descending to a minus quantity for the ones that are found to be very difficult. This indicates that it may not have been very well covered in the lessons. On the other hand, it may be an indication that the question is particularly difficult or unfair, in which case the teacher has the option of disqualifying it.

DISCRIMINATION INDICES--The computer printout rates the ability of each question to distinguish between the top students, and students in the bottom half of the class, in the sense that one would expect the top half to do better on each question. The range shown in this index is from -1 to +1 and if the top half has done better than the bottom half, the figure shown will be a plus quantity; whereas if the bottom half did better on a specific question than the top half, the numerical quantity shown would be a minus quantity. This serves to alert the teacher to the need to check the question and see whether there are any ambiguities.

In addition to an analysis of how effective each individual question is in distinguishing between top and bottom half, the printout also shows the discriminatory ability of each of the statements that make up the question. This is done by showing what percentage the top half of the class gave as answers and what percentage the bottom half gave as answers. We expect that the bottom half would choose the wrong answer more often than would the top half.

The foregoing data will be made available within an hour if some urgency is shown, but the normal turn around time is overnight.

PHILOSOPHY 102 and 202 PROJECT

The following is the result of the experimental use of a programmed study-guide provided to students at Fanshawe College of Applied Arts And Technology in London, Ontario. The students were enrolled in a General Arts And Science Program and the course was Philosophy 102.

One study-guide was created by Quesgen during the fall semester, 1987, based on the last half of the course. A copy was provided to each member of two classes AFTER their mid-term test. Other than this resource, no other changes in methodology in the presentation of the course were made, and no other learning resources were provided, beyond what was already available to the students.

They wrote their final test on December 15th, which was identical to the mid-term, as to the number of questions, their, make-up, and the taxonomy levels. A comparison of the results shows a dramatic improvement as follows:

Mid-Term Test -	Median Mark	High	Low	A's	B's	C's	D's	F's
Class A	53.5%	84	28	1	1	4	9	9
Class B	50.375%	80	32	1	1	6	6	18

Christmas Test -	Median Mark	High	Low	A's	B's	C's	D's	F's
Class A	69.14%	96	36	7	3	6	2	3
Class B	68.29%	96	44	6	7	9	4	2

A preliminary survey of the class, as to the availability of the study-guide and its value, was done after the final test. The students were almost unanimous in crediting the availability of the study-guide for their improved performance.

An increase of approximately 35% over the mid-term test is quite remarkable, but some of that may be due to the fact that the students became more familiar with computerized testing as a result of the mid-term.

For the winter semester, we made study-guides available for the entire Philosophy 102 course and for its sequel, Philosophy 202.

In the introductory Phil 102 course the median mark in the midterm test was 64 and the mean, or average, mark was 66. In the final test, these improved to 72 and 69 respectively.

In the sequel Phil 202 course, some of the students had not taken the introductory course and their mid-term marks reflected this fact. The median was 48 and the mean was 51. However, the final test showed dramatic improvement to a median of 64 and a mean of 66.

The final grades distribution is significant:

	High	Low	A's	B's	C's	D's	F's
Phil 102	96	30	6	7	5	5	3
Phil 202	98	30	7	2	0	3	8

The students who achieved the A's were almost unanimous in crediting the study-guides for their success. The teacher stated categorically that he had never experienced so many A's in his many years of teaching the subject, and he noted that the number of A's was not due to high average marks for the classes as a whole.

Furthermore, many students improved their marks dramatically when they used the study-guides as directed.

In one case a student had 16 on the midterm and 96 on the final!

In another, it was 36 improving to 100!

We are continuing our experiments in other disciplines and will, therefore, have the results of broader based research with much larger samples.

SUMMARY

1. Computerized testing is far more advanced than we realize.
2. The Taxonomy of tests can be metered so as to meet standards fixed by educational institutions, vocational and professional associations, and as required by industry. They can be main-tained on local, regional, provincial, a Canada-wide scale, or world-wide.
3. Test Objectives can be more comprehensive thanotherwise
4. The ability to create comprehensive course outlines and study-guides for conventional education is greatly enhanced. They may include the creative use and effectiveness of case-studies, flow charts, schematics, diagrams and other devices. Industry can improve the effectiveness of their technical manuals, instructional guides, or even policy manuals with study-guides based on them.
5. The correlation between "conventional" test results and computerized test results is remarkable.
6. Testmarking,andfeedbackforstudents, areaccelerated.
7. The frequency of testing can be increased without increasing teaching costs, or teachers' workload.
8. Student progress can be monitored much more closely than with conventional methods.
9. Up-to-date Student Records can be maintained efficiently, and inexpensively.
10. Teacher evaluation can be more objective, consistent, and con-structive. Teacher accountability can be measured.
11. The economies are potentially astronomic, and can be effected without reductions in quality.
12. Opportunities for productive class discussion are enhanced when tests are taken up immediately after they have been written. The Socratic method of teaching has been adapted and enhanced by automation.
13. Progress toward self-directed learning can be realized.
14. Remote learning and access to learning for handicapped persons becomes a reality.
15. Table-top publishing can reach out to remote areas and bring copies of learning resources within the reach of millions of people who could not otherwise have access.

C.A.I. Modules in Soil Science

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INTRODUCTION

Principles of Soil Science is an introductory course offered during the first year to students in the Agricultural Diploma Program at the University of Guelph. While all the students have a minimum grade 12 education, some also may have come from the degree program and even have completed their degrees, the majority have no previous exposure to soil science and there are many with minimal background in science. It is difficult, if not impossible, to present the course material in a lecture format to students with such widely varying backgrounds and meet all the needs of a class of 150 to 200 students. In addition, besides the usual lack of good study habits and varying interests in the course material that are typical of many students, a portion of the class has diagnosed learning disabilities, and require more individual attention. To meet the needs of all the students, we have elected to develop computer-aided instructional modules for the course using VITAL (Versatile Interactive Teaching and Learning System).

ABOUT VITAL

VITAL offers independent learning that:

(a) provides a non-threatening learning environment
(b) is time and location independent
(c) gives individual attention to each student
(d) indicates the level of mastery of the subject matter achieved by the student

We have designed the modules to be highly interactive in order to capture the attention of the students and motivate them to complete each module. The student must respond to questions to proceed through the module and receives immediate feedback, either acknowledging a correct answer or directing to remedial information. The VITAL modules are meant to complement the lectures allowing more motivational examples of the basic course material to be presented in class. Use of VITAL by students was not made compulsory for completion of the course requirements.

FEATURES OF THE LEARNING MODULES

Each module contains a single specific learning objective which, including a self-test, can be completed within a relatively short time, usually less than 10 minutes. This gives the student an early sense of achievement which is essential for motivation and learning; it also allows students to easily complete a module during breaks in their regular class scheduling.

The student controls their own flow through the module by electing from a Choice menu: the particular pathway selected depends on whether the student would like to use the module to cover material for the first time, continue through the module, review previous material, complete a self-test or exit the module. Immediate feedback and suggestions are provided for each student's response. If the questions are not answered correctly, the student can be directed to review material or to remedial exercises.

STUDENTS' REACTION

The response to VITAL by students, based on comments made in student evaluation, was generally very positive. Some of the comments were "I liked VITAL" and "More VITAL modules!". However, more than one-third of the class did not use VITAL. Furthermore, while all the top students worked through the VITAL modules, more than one-half of the poorer students did not complete all of the VITAL modules; some of these students did not use VITAL at all. It thus seems that the better students have taken full advantage of this new technology while the students that could benefit most have been slow to adopt it. Our effort now has to be directed to ensure that those students which need more help, choose to use VITAL.

University Industry Co-operation in Teaching: An Example in the Field of Modern Analytical Chemistry

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For the past several years many post-secondary educational institutions have been unable to purchase sufficient equipment to ensure adequate state of the art practically significant in the case of the institution such as the Ryerson Polytechnical Institute which has primarily built its reputation on the excellent practical skills of its graduates.

Recently, in the field of chemistry, this situation has become increasingly difficult as analytical instruments have become automated and the results generated by these instruments are stored and manipulated by microcomputers. Typically, the senior undergraduate teaching laboratory will contain instruments which do not have autosamplers and which are rarely controlled by computer systems. Small amounts of data are generated in the experiments and this data is displayed by meters, chart recorders and possibly simple microcomputers such as reporter/integrators. There is no storage of experimental data and data reprocessing is not used as a means of solving practical problems. In general, the major emphasis of the laboratory session is on the chemistry of the analytical method and also often includes the physical and/or the chemical parameters involved in the analytical instrumentation.

In contrast, a modern industrial laboratory analysis system will frequently include an autosampler, computerized instrument control, dedicated microcomputers for data storage and reprocessing and, in some instances, a laboratory mainframe or minicomputer and/or a network connecting instruments and microcomputers. Unfortunately, due to inadequate capital equipment budgets, todays graduate will generally have had little experience with this modern equipment the use of which requires not only analytical chemical knowledge but also dedicated computer skills and a familiarity with the principles of automatically analysing or producing large numbers of samples.

This presentation describes a short lecture/laboratory module which was included in the third year of the Bachelor of Technology (Laboratory Sciences) program in a partial attempt to bridge the gap between the teaching laboratory and the working world. The necessary modern equipment was not available on campus either for teaching the students or for the faculty to develop the course material. It was, therefore, essential to secure the assistance of a major manufacturer of analytical equipment both to develop the course content and to present the material to the students.

The course module consisted of two lecture hours and a three hour practical session. Both the lecture and laboratory sessions were developed co-operatively by the faculty member and a technical representative from the equipment manufacturer. The lecture sessions were presented by the faulty member and the laboratory sessions were led by two technical personnel from the industrial corporation, who also supplied, demonstrated and supervised the students' use of the equipment.

The major focus of the lectures was a review of the commonly available chromatography data management and instrument control systems with emphasis being placed on the equipment which was to be used in the practical session. The practical session introduced the students to chromatographic problem solving by using data reprocessing with two types of data station. The data stations were not connected to analytical instruments and data from chromatographic runs was pre-stored in the computer memories prior to the practical session. Apart from convenience, this approach focused the student's attention on the data manipulation aspect of the experiment rather than on the chemical analysis, however, knowledge of the principles of chromatography was essential to carry out the experiments.

The reason for developing course material in this way is to give senior students the necessary exposure to modern state of the art equipment which is not available on campus.a However, in addition to this major objective, some additional advantages were found. These included:

1) the experiments were based on the experience of the technical personnel in their field work and included the errors most often made by users of this equipment
2) the students learnt from young scientists with a high level of technical expertise (role-models)
3) the equipment costs and other operating costs (not labour) for the practical sessions were nil and
4) the faculty member had the opportunity to learn first hand about the equipment, to work with it, and to gain a complete knowledge of its potential.

There are, however, two possible disadvantages to using this approach for solving the practical problem of a lack of available modern equipment. The major disadvantage is that it requires a large amount of faculty time to become familiar with the equipment and to develop course material jointly with external personnel. The minor problem is a timing problem. In general, equipment can only be borrowed for teaching purposes when it is not needed for other purposes. This can mean that the order of all the course material is dictated by the availability of one set of equipment and may not be the most satisfactory for the overall course. A further aspect of this problem is that the faculty member will generally have to fit in between the company representatives' other commitments both in developing the course content and in presenting the material. Unfortunately, this may not always be possible. Nevertheless, the particular course material described here, was found to have provided a very productive and positive experience for both the students and for those of us who were involved in its preparation and presentation.