THE DESIGN, DEVELOPMENT AND EVALUATION OF A PERSONALIZED SYSTEM OF INSTRUCTION IN A CHEMISTRY I COURSE AT A COLLEGE OF ADVANCED EDUCATION

by

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To my wife, Diane

This thesis contains no material which has been submitted for the award of any other degree or diploma in any tertiary institution and, to the best of my knowledge and belief, this thesis contains no copy or paraphrase of material previously published or written by another person, except where due reference is made in the text of this thesis.

William F. Donovan

November 29th 1977.

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ABSTRACT

This thesis describes the design, development, and evaluation of a personalized system of instruction (PSI) in a Chemistry I course at an Australian college of advanced education.

The research project had three main aims:

1. To design and develop integrated, self-paced theory and practical courses in Chemistry I using the PSI technique.

2. To construct a course evaluation model and to evaluate the Chemistry I course using this model.

3. To investigate the relationship between personality and performance of students in the PSI Chemistry I course and a more conventionally taught Biology I course.

A description is given of the operation of the PSI Chemistry I course. Essentially the five major features of PSI, as identified by its founder, F.S. Keller, were incorporated in the course. These features were: self-pacing; mastery orientation; student proctors; an emphasis on written and oral communication; and motivational lectures.

PSI derives its rationale from two major principles of educational psychology. Firstly, that students should be provided with a set of terminal behaviors which clearly specify outcomes; secondly, a system of rewards should be set up and managed so that their application is contingent upon positive behavior by the students. Personalized systems of instruction

can be traced as an application of behavior theory in conjunction with the social aspect of treating individual students as important.

The research design employed was based on the case study approach to the course evaluation process. A multiple methods evaluation strategy was developed to implement the model, with a particular extension of the model to self-evaluation by the instructor. The strategy involved formative evaluation in the initial design and development stages of the project.

The process of course design and development was identified as comprising the first stage of the evaluation strategy. The second part of the strategy could be termed the illuminative stage in which major issues involved in the PSI course were identified and then focused on. The research methods used were: observation, feedback slips, analysis of course materials, questionnaires, interviews, outside evaluator assistance, student records, written comments, and a pre-test, post-test study of the relationship between personality and student performance.

A feature of the PSI course was the demands it placed on the management of a complex teaching-learning system. As well as incorporating the elements of the original Keller plan, a PSI learning centre was designed and constructed in order to provide a suitable social learning environment. It was found possible, within the normal constraints of a college system, to run a resource efficient, cost-effective, innovative PSI program in Chemistry I.

Performance of students in the PSI course, as measured

by grades achieved, were at least as good as in the conventional course of 1973. The problem of procrastination and dropouts was successfully combated by several measures.

From course questionnaire results it was concluded that students reacted very favourably to the PSI Chemistry I course and that their interest in the subject had increased during the course.

A pre-test, post-test study of the relationship between personality and performance was carried out. Overall, the results suggested that conscientious, responsible, and conforming students performed well in both a traditional biology course and the PSI Chemistry I course. In particular, however, it was found possible to pre-determine from personality profiles which students had greater probability of being at risk in the PSI Chemistry I course. Such students had personality profiles whose Californian Personality Inventory scores varied, in any direction, by large amounts from the mean scores. A further finding was that divergent thinkers were more likely to succeed in PSI Chemistry I than convergent thinkers.

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CHAPTER I

THE CONTEXT

1.1 *Introduction*

This thesis describes the design, development, and evaluation of a personalized system of instruction (PSI) in a first year chemistry course at an Australian college of advanced education. The author undertook the research and also taught the course during 1974 and 1975

It was decided to introduce PSI for the following reasons:

a) PSI is a complete and integrated educational system. Earlier experiments by the author over a number of years, to improve the teaching-learning process, had proved to have marginal value and were often developed in a haphazard fashion. Experiments, for instance, had been done with various teaching aids such as film loops and videotapes, with tutorial group discussion methods, with project laboratory work, and with the use of multiple-choice questions in examinations. (Donovan, 1973; Donovan, Finney and Thomas, 1970)

b) It is based on clearly formulated learning principles.

c) Reports of overseas experience in the use of PSI, especially in the "hard sciences", were encouraging. (Green, 1971; Leo, 1973)

d) The desire to make teaching more individual and personal and the opportunities to do this in a newly-formed college of advanced education.

The research project undertaken had three main aims:

I To design and develop integrated, self-paced theory and practical courses in Chemistry I using the PSI technique.

II To construct a course evaluation model and to evaluate the Chemistry I course using this model.

III To investigate the relationship between personality and performance of students in the PSI Chemistry I course and a more conventionally taught Biology I course.

Keller (1968), one of the four originators of PSI, and Green (1971), who have done much to foster the development and use of the system, have identified PSI's five important characteristics as:

i) Self-pacing

Within the constraints of semesters or terms, students can progress at a rate they set themselves.

ii) Mastery oriented

Students are required to demonstrate in repeatable tests a high level of mastery of the course work specified.

iii) Student proctors

Other students are used to handle the high information feedback capacity of PSI by distributing, supervising, and marking tests and in carrying out other clerical functions.

iv) Written and oral communication

Precision of written communication is obtained by clear specification of learning objectives in study guides and in the construction of readiness tests. Oral communication is fostered in the interactions between students, proctors, and staff.

v) Motivational lectures

Lectures are used only for motivation not for communication of information.

According to Ryan (1974), in a review of PSI, these basic features are arranged into a teaching/learning system that derives its rationale from two major principles of educational psychology. Firstly, that students should be provided with a set of terminal behaviors which clearly specify expected outcomes. Secondly, a system of rewards should be set up and managed so that their application is contingent upon positive behavior by the students. PSI can be traced as an application of behavior theory as a generic descendant of programmed learning. (Hess and Lehmann, 1976)

1.2 *The PSI Chemistry I Course*

The course described and evaluated, Chemistry CH10, hereafter called Chemistry I, was a one-semester course in general chemistry taken by beginning students in the Applied Chemistry degree course and as a service course by students in other applied science departments. Teaching assistance was provided by part-time demonstrators in the laboratory and student proctors in the theory section.

The students taking the course had diverse backgrounds in age, sex, degree course, nature of enrolment, and previous educational achievement. Table I shows the populations for the two years 1974-75 presented in the context of a four-year program.

TABLE 1

Student Population 1973-76

Chemistry I

	1973	1974	1975	1976
Total (N)	21	15	29	41
Male	11	10	14	27
Applied Chemistry	7	4	8	5
Pharmacy	N/A	N/A	17	24
Medical Technology	10	9	4	11
Other	4	2	-	1
Age < 20	10	9	16	25
20-30	10	5	8	14
> 30	1	1	5	2
Part-time	14	10	10	7

The course was taught following the PSI format as described by Keller (1968) and Green (1971). The subject matter of the theory course was divided into sixteen reading units and three review units, the practical work into twelve units. Two major sources of content were used: the material previously taught in the conventional course and some topics from the second-year syllabus. Second year courses were analysed for necessary pre-knowledge, and staff teaching these courses were interviewed to check on this analysis. As might be expected, staff often appeared to have exaggerated pre-knowledge requirements for their respective courses. Presented with a large amount of material that could potentially be put

in the Chemistry I course, it was necessary then to prune it to manageable levels. Ultimately much of what was included was a question of the writer's subjective judgment. The course outline, however, was subsequently accepted by the College's external course accreditation committee. This course outline contains policies and procedures and gives a clear indication of the scheme of assessment and grading. (See Appendix 1.)

For each unit of the course a study guide was prepared using the procedure diagrammed in Figure 1. A sample study guide is attached as Appendix 2. Each course unit approximated to a week's work. For a full-time student this was equivalent to a quarter of his classwork and study time.

A study guide typically comprised a brief introduction; approximately four objectives covering the course unit; a study approach in which specific reference is made to the course textbook, alternate reading material and audio-visual sources; a set of problems or a self-test covering all the unit objectives; and usually some supplementary reading references.

Before commencing the course it was also necessary to select and brief proctors, to design and furnish a learning centre, and to decide on how the project was to be evaluated. These will be discussed in more detail later.

Before the start of the course, the instructor gave an introductory lecture to set the scene for the study of chemistry and for the operation of the PSI system. The study guide for the first unit was then distributed. When the

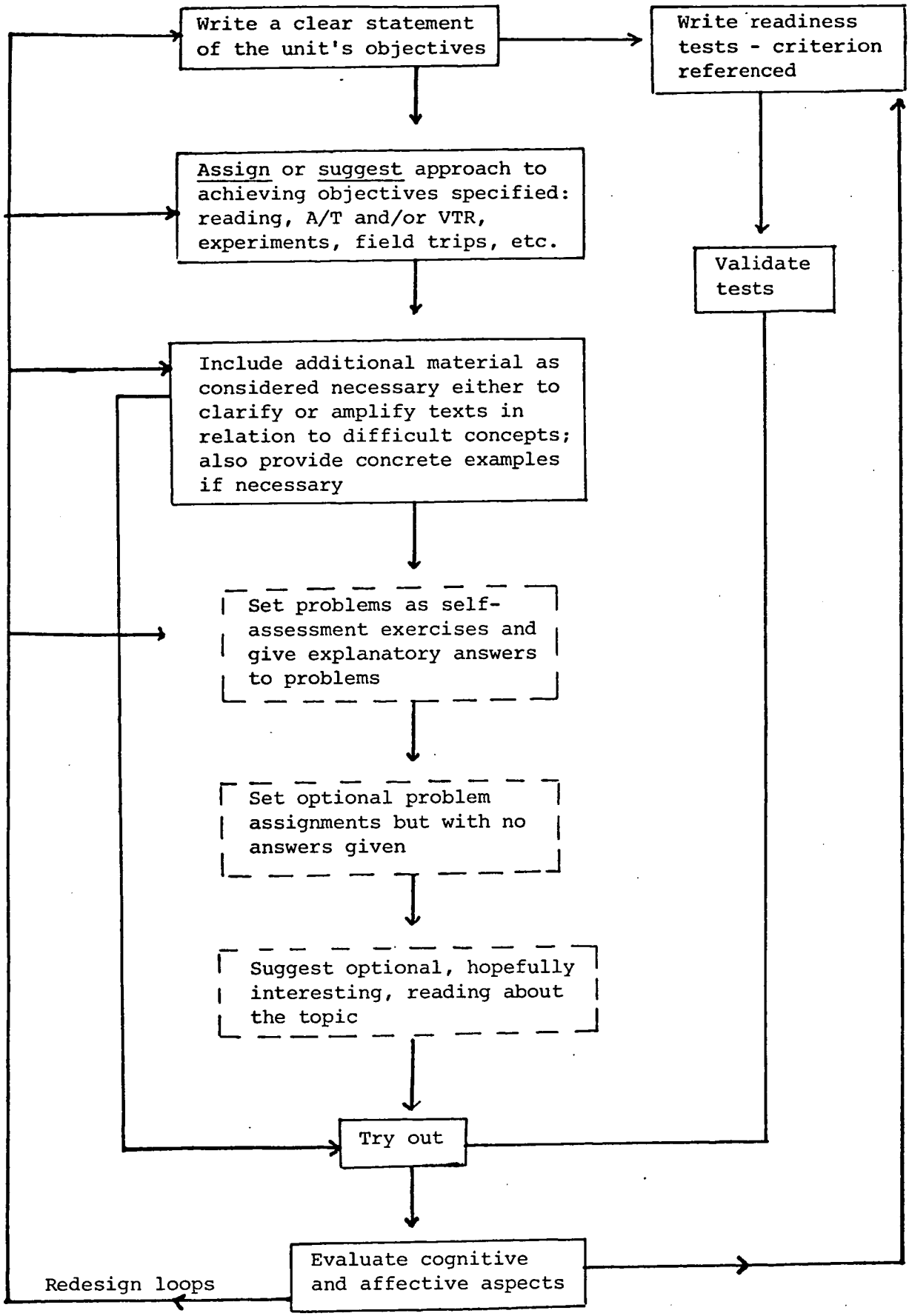


Fig. 1 Study guide design - Flow chart

optional aspects of the study guide

students felt they had mastered the material of the unit they presented themselves to a proctor in the learning centre to take a readiness test. These tests were designed to be completed in less than twenty minutes. The type of tests used varied. Some comprised short questions covering each objective, others ten multiple choice questions, an essay, review-type question or a problem covering all the objectives. When completed the test was marked immediately by one of the proctors on an individual basis in the presence of the student. If the student obtained 100 per cent he passed, if he scored at least 85 per cent of the maximum marks on the written paper and could verbally satisfy the proctor about his mastery of the rest, he likewise passed and he went on to the next unit. If a mark of less than 85 per cent was obtained the proctor pointed out the mistakes and sent the student away to do more study on the unit before taking another test on the same unit. Students with obvious learning difficulties were referred to the instructor for tutoring. This process was repeated for the rest of the theory units. Successful completion of the 19 units gave a pass in the subject, providing the student also passed all the practical units to the satisfaction of his demonstrator. The practical course also operated in the PSI manner, satisfactory completion of 12 units constituting a pass.

The course, as it operated, can be seen as a presentation-response-consequence cycle as illustrated in Figure 2. In the traditional lecture system this cycle is sluggish, often taking a year to operate. The lecture is the

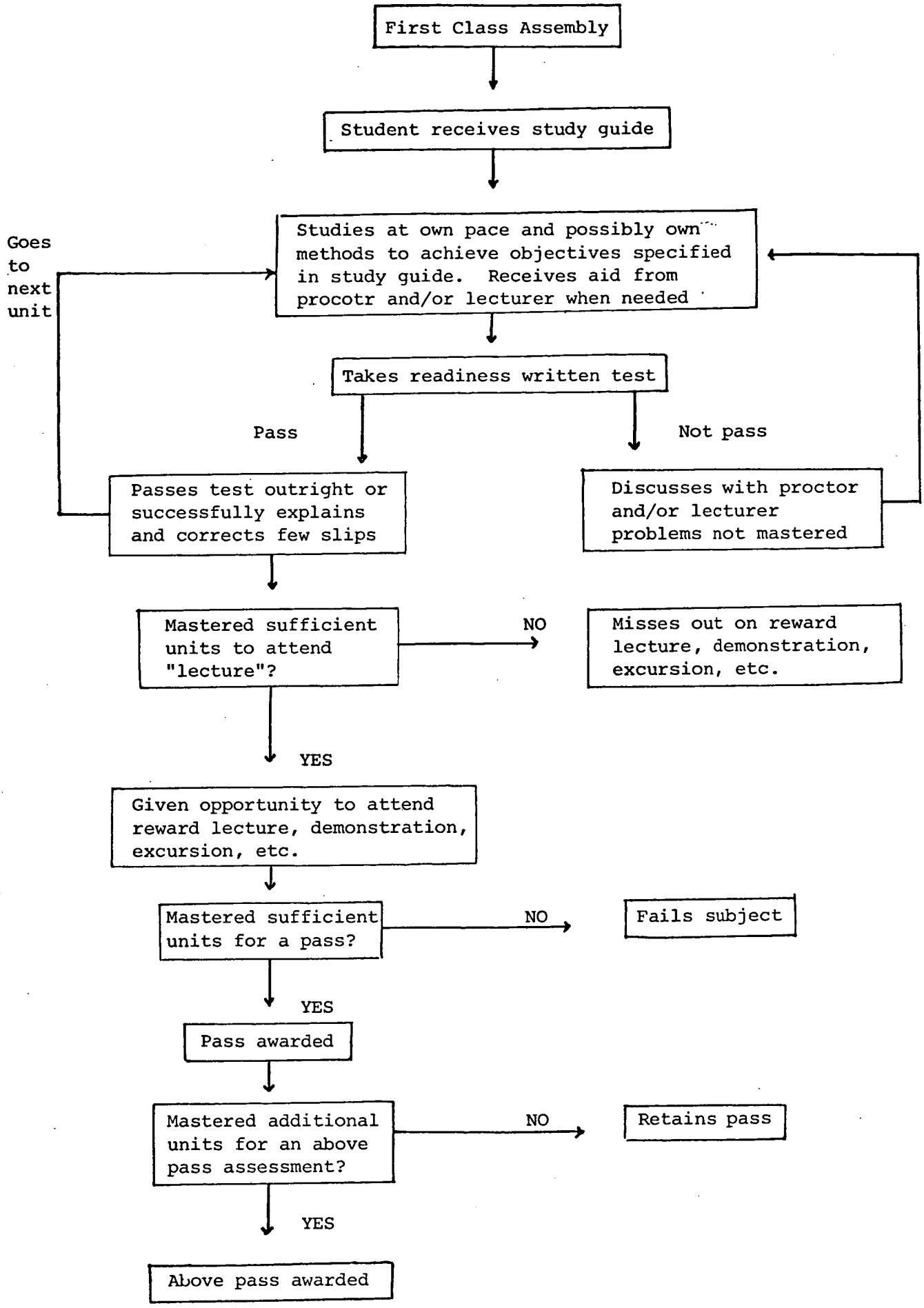


Fig. 2 Presentation, response, consequence cycle - usually on a weekly or part-weekly basis

presentation, the student responds in a final examination, with his non-negotiable result being the consequence. In PSI the cycle occurs frequently and on an individual basis. The course work is presented via written study guides and alternative media approaches. The student takes a readiness test and immediately learns his result and, as a consequence, can rectify his lack of knowledge or be made aware that he has mastered the material of the unit.

The initial trials of the study guides (and of the PSI system) were carried out in 1974 with a group of 15 students. It was a deliberate policy of the instructor to produce several units initially and to then construct further units when the fastest student was about two steps behind. This had the advantage of feedback from the students on their capacity to handle the units, and their rate of progress. In the second stage of course development, 1975, information gained from the trial group was used to modify the units and study guides. This process is described later under formative evaluation. Students completing this course took Chemical Principles CH20 in the second semester. This course was similar in structure to the General Chemistry course and also operated on the PSI mode.

In both courses, successful completion at mastery level of all units guaranteed a pass in the subject. A higher grade - credit, distinction or high distinction - could be obtained by completion of optional theory and practical units and by obtaining specified marks on a final examination.

The course content for each subject, CH10 and CH20 is

summarized as theory and practical unit titles and presented together with a list of texts used in Appendix 3.

The pilot course in 1974 operated from a temporary learning centre constructed at the back of a study carrel area in the college's resource material centre. This consisted of an office plus 10 carrels separated from the rest of the area by demountable partitions. The practical component of the course was held in an old technical college laboratory three miles away in the centre of the city. The three proctors used were final-year Applied Chemistry students who volunteered for the task and were paid $2.50 per hour.

In 1975 a learning centre (see Figure 3) was constructed in the Engineering building on the new college campus. This centre provided more adequate facilities for private study, and audio visual carrels as well as an informal coffee area. Again, the laboratory part of the course was held in the technical college. The six proctors used for the course were selected from eight volunteers and paid $3.00 per hour. The proctors were rostered over the 12 hours of test sessions so that the proctor/student ratio was never more than 10 : 1.

Every effort was made to provide in the learning centre a suitable environment for the PSI course. Students selected furniture for the informal area and paintings to put on the walls. The learning centre was later shared with other PSI classes in Physics I and Surveying I. However, during scheduled test sessions, the class involved had priority over use of the centre's facilities. Of the 12 hours available for testing in Chemistry I, only two hours overlapped with a

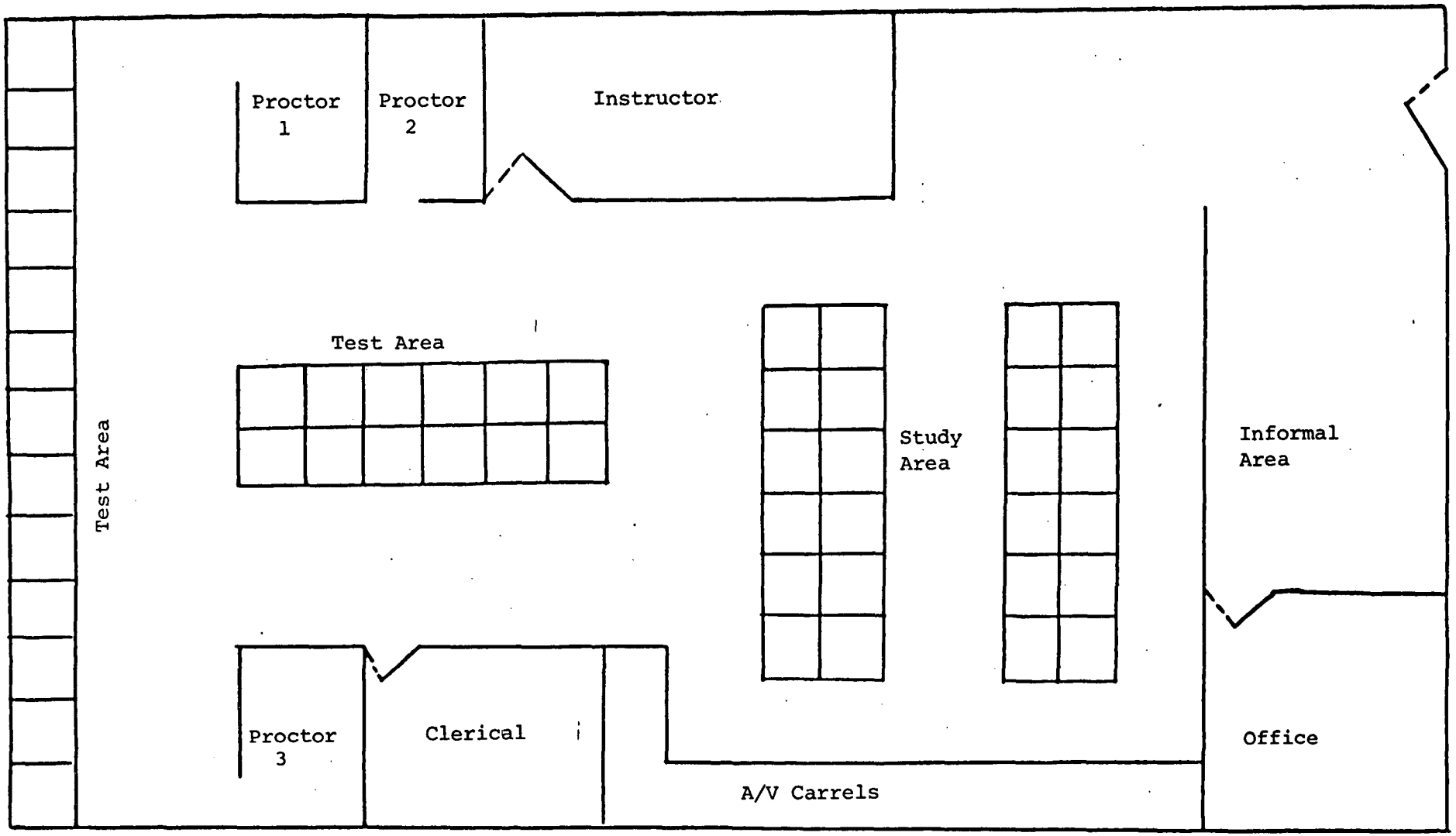


Fig. 3 PSI Learning Centre 1975

test session in another subject - Surveying I.

The next chapter deals with the theoretical basis and genesis of PSI and with a review of the current research literature. The following two chapters are concerned with the research strategy, results and discussion with special reference to the study of the relationships between student personality and performance in the PSI course as compared with performance in a more conventional course. In the final chapter, the major findings of the research are summarized and suggestions for future study are proposed.

CHAPTER II

THE BASIS AND GENESIS OF PSI - A REVIEW

Each issue of the PSI Newsletter (1974-77) contains the following definition:

> Personalized Instruction is the teaching of courses as if each student were a class of one. This is accomplished through the use of self-instructional material (study guides) and a corps of student helpers (proctors). The Personalized System of Instruction (PSI) is a well-defined system based on psychological principles of learning, for administering personalized instruction. [p.2]

2.1 *History*

PSI had its beginnings as the Keller Plan at Columbia University (Keller, 1968) but was based on a system first used in 1963 in Brazil when Keller and Sherman, and two Brazilians, set up courses in psychology at the University of Brasilia. In a later account of these beginnings, Keller (1974) quotes from his diary of 29 March 1963:

> Rodolfo (Azzi), Carolina (Bori) and Gil (Sherman) arrived yesterday ... from Washington .... They were all filled with their trip, which seems to have been quite a success. At Boston and Cambridge they talked with B.F.S. (Skinner), Dick Herrnstein, Murray Sidman, Peter Dews and Og Lindsley .... At Brown, they met Posi Pierrel, Harold Schlosbergy, Don Blough, Loren Riggs and others; at Washington they visited I.B.R., Walter Reed, Maryland U, and talked with many others. We discussed the trip and ended with an exciting session on the problem of 'how to teach'. Rodolfo's presentation of Charles Ferster's thinking led us around to a tentative decision on the procedure to be used in Brasilia - a procedure that combines the features of Psychology 1-2 (Columbia's first course) with ... B.F.S.'s Natural Science course at Harvard and C.B.F(erster)'s Behavioral Technology set-up at I.B.R. Details must be worked out, but the course of training promises to be one

of the most exciting and most radical ever given in a University setting.

Keller and Sherman had only a limited opportunity to introduce their new instructional technique before a political revolution in Brazil forced them to leave the country. Both subsequently moved to Arizona State University. Here they set about implementing their ideas on PSI and developed a system of instruction, which was vividly described by Keller (1968) in his article, "Good Bye, Teacher ..." Since then PSI has been adopted by teachers in many parts of the world and the literature on the subject has been greatly expanded.

2.2. *Genesis of PSI*

In tertiary education there has been, over the past twenty years, an increasingly heterogeneous student population with increasing enrolments followed by higher staff-student ratios. In this context the use of the traditional lecture, tutorial, final examination format of teaching has led to a series of educational problems. Born (1970) has described these as:

i) Loss of the personal-social aspect of the educational process;

ii) Decreased speed and quality of feedback to students and instructor;

iii) Increased reliance on the lecture for transmitting critical information;

iv) Grading of students on a statistical curve of relativity rather than on personal mastery of material.

It would seem that in an age of student diversity, in order to produce an education system responsive to its consumers and supporters, the teaching-learning process must be made to adapt to a wide range of problems. Consequently educators have devised systems of individualized instruction which cover a wide range of methods based on the following assumptions:

a) no two individuals are alike,

b) many individual differences affect a student's progress,

c) if instructional presentations vary in response to individual differences, most learners can achieve the same terminal performance. (Bloom, 1968).

Hess and Lehmann (1976) identify eight individualized instructional methodologies that have been developed to help overcome student learning problems. They selected 15 instructional features of individualized instruction and related these to the different instructional methods (see Figure 4).

One factor to be taken into account in interpreting this Hess and Lehmann analysis is the rather arbitrary selection of instructional features. For instance, how can 'proctors' be distinguished from 'immediate feedback' and 'explicit contingencies'? Later in this chapter such overlap will be analysed in more detail. The assignment of features in Figure 4 was based on statements of early practitioners and on frequency of use of the features in current literature descriptions of a given method. Even though it is unrealistic to cite features as

individual, i.e. isolated variables, it can be seen from Figure 4 that the first six methods which bear common roots with programmed instruction have very similar features. This could well be expected as their founders were closely associated professionally. "Of the eight methods cited only programmed instruction, PSI, and the audio-tutorial methods enjoy coherence, wide use and distinctiveness" (Hess and Lehmann, 1976). Of these, programmed instruction can be seen as the forerunner to PSI.

INSTRUCTIONAL METHODS	Outcome Specification	Repertoire Assessment	Individual Prescription	Learner Select Objective	Active Responding	Explicit Contingencies	Immediate Feedback	Frequent Feedback	Successive Approx.	Self Pacing	Mastery Criterion	Proctors	Critical Info Written	Multimedia Presentations	Computer Assistance
Programmed	X				X	X	X	X	X	X	X		X		
Computer Assisted	X	X			X	X	X	X	X	X	X		X		X
Personalized	X				X	X	X	X	?	X	X	X	X		
Precision	X				X	X	X	X	?	X	X	X	X		
Contingency Management	X	X	X		X	X	X	X	X	?	X	X	X		
Individually Prescribed	X	X	X	?	X	X	X	X	X	X	X		X	X	
Audio-Tutorial	X			X	X		X	X	X	X	X		X	X	
Mastery/Modular	X			X	X		X	X	?	X	X	?	X	X	

INSTRUCTIONAL FEATURES

Fig. 4 showing Hess and Lehmann's (1976) selection of instructional features and the instructional methods they relate to.

2.2.1 *Programmed Instruction (PI)*

Macdonald-Ross (1969), Unwin (1967), and Hartley (1973) suggest that PI can be classified on the basis of the following characteristics:

i) A clear specification of performance objectives;

ii) The use of diagnostic tests as a measure of performance;

iii) Immediate feedback to the student;

iv) Self-pacing is allowed;

v) The learner is active rather than passive;

vi) The materials are arranged in small steps of appropriate size.

PI has involved detailed attention to the sequencing of materials and has developed along linear programming lines (Skinner) and into branching sequences (Crowder) but at all times attempting to achieve gradual transitions from one step to another in the learner's performance coupled with immediate reward for correct responses.

Rather prophetically Macdonald-Ross (1969) wrote of programmed learning: "Although PI has not produced a panacea for all learning ills ... some of the characteristics are likely to prove permanent and valuable contributions to educational practice ..." [p.97].

2.2.2 *The Personalized System of Instruction (PSI)*

In 1968, Keller's article,

"Good Bye, Teacher ..." appeared in the Journal of Behavior Analysis. According to Keller the main features of PSI are:

i) Individual pacing

Within the constraints of semesters or terms, students progress at the rate they set themselves. Some speed along and are not held back by slower students, whereas the slower students are not forced to proceed at the rate of the quicker students. All, however, are required to develop a good grasp of the material.

ii) Mastery oriented

Students are required to demonstrate high levels of performance on tests, the so-called mastery aspect. The units of work, however, are relatively small and it is usual for students to take one, two or even more readiness or mastery level tests a week. This is to reward and reinforce learning immediately and to encourage a continuous rate of progress. In order to minimise fragmentation and to enhance concept coherence, review units are used periodically and these also must be passed at the mastery level.

iii) Proctors (Student tutors)

It must be apparent from what has already been mentioned that PSI requires high information feedback handling capacity - much higher than

in the lecture or tutorial situation. To emphasise this point it should be mentioned that benign, or non-threatening, testing methods are used. Thus a number of different tests for each unit are prepared in advance and a student may be given any one of these tests. If he fails at his first, second or even later attempts he suffers no penalty. Mastery, albeit eventual, is the crucial factor rather than the number of tests taken. To handle the amount of information generated by this testing program, student proctors are used. It is generally recommended that a proctor be responsible for not more than ten students. It is the proctors in the system which permit repeated testing, immediate scoring, unavoidable tutoring and much of the personal-social aspect of the educational process.

iv) Written and oral communication

In order to clarify and make explicit the learning tasks required of students, carefully constructed written study guides are prepared. Precision of communication is fostered in students via the written readiness tests. However, oral communication is also encouraged between instructor, proctors and students on either a one-to-one or small group basis. Discussions occur in relation to the interpretation and use of the learning experiences suggested by the study

guides. Students are also required and encouraged to orally explain, justify, and clarify their answers on completed tests.

v) Motivational lectures

Lectures are used in the PSI method to motivate students and are not used to communicate critical information required of the course. It is necessary for a student to qualify for permission to attend by completing a requisite number of units by a specified date.

It is clear from this examination of these basic characteristics that PSI has its genesis through PI in that it has its roots in response contingent, feedback, and reward theory from which PI was developed. In this regard, Keller (1968), saw the similarities between PSI and PI as "the same stress upon analysis of task, the same concern with terminal performance, the same opportunity for individualized progression, and so on." [P.7]. A more detailed analysis of the theoretical basis and operation of PSI is given in the next section.

2.3 *Theoretical Basis of PSI*

What then is PSI? What are its theoretical bases? What are its main instructional principles?

Sherman (1974) defines PSI as "a well-defined system based on psychological principles of learning for administering personalized instruction" [p.2]. It is appropriate, therefore, at this stage to look at human learning and to

focus attention on the basic principles of learning derived from educational psychology.

Lippincott (1973) claims there is evidence that human learning is controlled in large measure by three main factors:

i) heredity,

ii) personal hierarchy of values,

iii) social environment.

While there is nothing a teacher can do about the first of these, the latter two may be subject to some influence in the educational process.

In particular, an individual's voluntary behavior is susceptible to influence from an underlying hierarchy of values (Lippincott, 1969). Learning, then, may be viewed as contolled in large measure by this value hierarchy.

In the context of tertiary education, where complex learning patterns are involved, the student's value hierarchy must be receptive to adding more knowledge, to acquiring new levels of understanding, to the expansion of the value sphere, and to a continuous re-evaluation of priorities among values. It may be then, that the major barrier to learning in a tertiary student is a conflict of values.

PSI can be viewed as a set of teaching principles specifically oriented towards overcoming some of the value conflicts inherent in tertiary learning. These will be discussed in more detail in section 2.3, and only one illustration is given here. Students often just want a "pass" in a subject perhaps because they have to do that subject

for any one of a variety of reasons. Thus a student in a conventional final examination oriented subject may only do a minimum of work, with a minimum of effort to obtain a bare pass. This is hardly conducive to the acquisition of knowledge and understanding about the subject. PSI, however, has its emphasis on reinforcement through the mastery feature and through positive and helpful interpersonal interactions. This should provide a suitable environment to help motivate the student to pursue the acquisition of knowledge and understanding of the subject with a more positive attitude and with diminished value conflicts.

Let us now turn attention to the basic learning theories and how PSI fits into the framework of these theories. Hilgard (1966) divides learning theory into three types:

i) stimulus-response,

ii) cognitive,

iii) motivation and personality.

This division appears to have general acceptance amongst many authors. It is the first of these types that relates most closely to the human behavior of primary concern in this thesis.

In this vein, Staats (1968), claims that the principles of classical and instrumental conditioning should form the basis of an explanation of complex human behavior. From these principles it ought to be possible to derive more complex stimulus-response mechanisms that would help to explain various aspects of human behavior.

The principle of classical conditioning is the process by which an initially neutral stimulus acquires the capability

of eliciting a response.

Within classical conditioning there is also an higher order process whereby a conditioned stimulus elicits a response, but transfers this function to any new stimulus with which it is paired.

Later experimenters, like Watson, developed a more rigid behavioristic theory of conditioning that had as its main concept that man is a neutral-passive or reactive organism with innate reflexive drives and emotions.

Of somewhat later origin than classical conditioning has been the development of instrumental conditioning. Thorndike in his law of effect studies argued that behavior was initially random, but that eventually that behavior's consequences started to select behaviors more effective than the others. The basic thrust of Thorndike's theories was that through conditioning specific responses came to be linked with specific stimuli. The main principle of instrumental conditioning derived from the work of Thorndike and others is that of <u>reinforcement</u>. When an unconditioned stimulus, a reinforcer, is presented following a response, the response will occur more frequently. It follows that, if a response is already strong, it will be maintained in strength by being followed by such a stimulus.

Positive reinforcement can be thought of in terms of reward presentation and negative reinforcement in terms of punishment removal.

Reinforcement may assume a variety of schedules; the frequency of a response being altered by the proportion of

responses reinforced. According to Skinner (1953) there are two basic schedules:

i) Continuous, that is, reinforcement occurring with each operant response;

ii) Non-continuous in which a predetermined time schedule governs reinforcement.

In this latter category Skinner describes many schedules of reinforcement. For instance, fixed-ratio in which reinforcement follows a set number of responses; variable ratio in which reinforcement varies within a given range, and fixed-interval where reinforcement occurs at given time intervals.

It is interesting here to look at Keller's contribution in the reinforcement area. Keller and Schoenfeld (1950) stated a principle of secondary reinforcement that says: "A stimulus that is not originally a reinforcing one can become reinforcing through repeated association of one that is." That is, through classical conditioning a stimulus acquires the power to operantly condition.

Staats (1968), however, believes that Keller and Schoenfeld attempted to make classical conditioning secondary to instrumental conditioning by accounting for conditioned reinforcement in terms of instrumental discrimination learning; a criticism he extends to cover Skinner's work because it fails to extend the principle of classical conditioning to complex human behavior. To Staats most human learning involves several behavioral principles, as well as many stimuli, controlling many responses.

This may be so and those who see PSI as wholly based on

Skinnerian operant conditioning are probably looking for an easy answer to the more complex question of the basis of PSI. True, Keller was heavily influenced by Skinner but he was also influenced by his conviction that individual students are important.

At the conclusion of his article, "Good Bye, Teacher ...", Keller (1968) had this to say:

> My days of teaching are over. After what I have said about efficiency, I cannot lay claim to any great success, but my schedule of rewards was enough to maintain my behavior, and I learned one very important thing: the student is always right. He is not asleep, not unmotivated, not sick and he can learn a great deal if we provide the right contingencies of reinforcement. [p.12]

Sherman (1974), one of the founders of PSI, also claims that this caring for the needs of individual students as much as reinforcement theory led Keller and himself to the development of PSI.

In this context the teacher ought to be able to manage the learning of individual students by controlling the reinforcement of their observable learning behaviors. Thus the teacher influences learning outcomes by the specification of learning objectives; as is done in PSI. The clear specifications of objectives is the first and a major portion of the study guides used in PSI.

In Skinner's view the application of reinforcement theories of learning was to be made through programmed instruction and the development of teaching machines. Programmed learning as seen by Skinner (1953) was of a linear type, in which great attention is placed on the sequencing of instructional materials with particular attention to the

reinforcement of correct responses. Skinner's linear programming presents a series of frames to a student. A frame constitutes a single instance of a reinforcement contingency. It consists of a discriminative stimulus in the form of a question. The student's answer is the response, the reinforcement being the "correct feedback".

PSI, on the other hand, while descended from PI can be seen as quite different to Skinner's programmed instruction. Firstly, the frame size is much larger and, secondly, the course structure in not necessarily linear.

Keller (1968) describes the operation of PSI as:

> The principal steps of advance are not "frames" in a "set", but are more like the conventional home-work assignment or laboratory exercise. The 'response' is not simply the completion of a prepared statement through the insertion of a word or phrase. Rather, it may be thought of as the resultant of many such responses, better described as the understanding of a principle, a formula, or a concept, or the ability to use an experimental technique. Advance within the program depends on something more than the appearance of a confirming word or the presentation of a new frame; it involves a personal interaction between a student and his peer, or his better, in what may be a lively verbal interchange, of interest and importance to each participant. The use of a programmed text, a teaching machine, or some sort of computer aid within such a course is entirely possible and may be quite desirable, but it is not to be equated with the course itself.[p.7]

Reinforcement in PSI, in the specific learning principle sense, comes especially from the mastery feature and from positive and helpful interpersonal interactions with proctors, the instructor and with other students.

PSI allows mastery by:

i) breaking the course into small enough units;

ii) communicating to the student explicitly what is to be mastered;

iii) using two-way face-to-face communication in the evaluation of mastery.

In PSI, therefore, the principle of reinforcement may be seen to be employed. A unit test constitutes a contingency of reinforcement, the discriminative stimulus being in the form of questions. The student's answers, both written and verbal, are the response. The reinforcing stimulus is the earned grade credit and the proctor acknowledging this by showing the student that he has attained mastery level on the test answers.

Social reinforcement consists of feelings of accomplishment and of esteem, clearly expressed by other people on achievement. This latter point illustrates the emphasis placed in PSI on the importance of the individual student and the provision of a supportive environment to assist students in their learning.

The schedule of reinforcement employed in PSI is clearly of continuous and rapid reinforcement. Immediately on completion of a unit test, the test is marked by a proctor and the student knows whether he has passed or not. The knowledge immediately obtained by the student of his success provides a further motivational aspect of reinforcement that is central to the operation of PSI. Both this knowledge of success and the proctor's assistance are important components of the operation of PSI.

Green (1971) described PSI in terms of a presentation,

response, consequence cycle that is short and rapid. The traditional lecture, plus end of year examination, has one cycle. PSI has a series of short cycles. In the longer and usually 'sluggish' cycle of the conventional lecture format students are not required to demonstrate mastery - 50 per cent will do; they do not know in any specific sense what they are required to know and for what they will be rewarded. The "consequence" of the final examination does not assist learning because students do not know very much about how the consequence was decided and it is too late to do much about it in any case.

To apply mastery criteria to learning, the clear specification of learning outcomes is necessary. According to Gagné (1970):

> The teacher is the manager of the conditions of learning. What he says to the student comprises the verbal communications and also the verbal stimulus content of the learning situation. What he points to or has the student look at in the surrounding environment becomes a part of the stimulus situation for learning. [p.324]

This emphasis on attainable objectives becomes critical to future student performance in a PSI course. These objectives which comprise the most important part of the PSI study guides must be expressed in terms of observable human performance, i.e. as performance objectives. Gagné (1970) and Mager (1968) stress this point. It is useless to ask the student to 'know' or 'understand' something at the end of a section of work if he is not told exactly how he is to perform or to demonstrate his acquired knowledge or understanding. Thus the objectives specified under PSI are performance

objectives.

Students should be able to demonstrate, under test conditions, that they know and understand the objectives formulated for the course units. This demonstrated mastery is linked with the reward of cumulative passing of units to pass the course subject.

The tests the students take during a PSI course are placed under stringent examination. Any faults in the tests are corrected. Proctors systematically record any faults in the tests or other materials. As far as the students are concerned, these are diagnostic tests and form the basis for discussion and negotiation between student and proctor. The student is encouraged to explain and justify his answers verbally. Thus reinforcement is immediate. Also PSI provides, because of its explicitness and immediate feedback, a self-improving system as far as the student is concerned.

For the PSI system to facilitate learning by the students, self-pacing can be considered as a step towards solving the major problem of individual student differences. Students do differ; they differ in previous experience, in intellectual and psychomotor skills, and in their needs and aspirations. Above all students learn different things at vastly different rates. This self-pacing in PSI courses allows the weaker students time to pace themselves in order to master the objectives of course units and at the same time allows the brighter student possibility of moving ahead of the main class stream. Selective negligence, that is, the deliberate omission of study on certain course topics, is not encouraged

as if often the case with scheduled lecture-final examination programs.

Other features of PSI also cater for the needs of individual students. The use of proctors to give individual attention to each student at the reinforcement stage is one of these. Another is the careful management of the PSI operation by the instructor. The instructor, freed from routine administration and test marking can pay more attention to problem students or to extending the brighter students. He can also organize the PSI system to help minimize procrastination and can provide alternative learning situations to suit all students.

PSI, therefore, has its roots in reinforcement theory and provides a teaching-learning situation that caters for the needs of individual students. These two major bases of PSI are treated in more detail, particularly in terms of reported research studies, in the following analysis of the five basic characteristics of PSI.

2.3.1 *Individual pacing*

Despite the fact that self-pacing appears to be at the heart of the PSI system, very little research has been reported on its benefits. Reports on comparisons between self-paced and teacher-paced groups have measured performance on a final examination. These have found no significant differences between the two groups. (Beneke and Taylor, 1975; Lewis, 1972; Robin and Graham, 1974; Semb *et al*, 1975).

Robin (1976), in a recent review in a wider study of behavioral instruction in the college classroom, claims that on the research evidence self-pacing is not necessary for behavorial instruction to be effective. Robin's review of the research literature was not confined to PSI but to a wider range of instructional variants on the behavioral instruction theme. Kulik, Kulik and Smith (1976) specifically reviewing research on PSI also found no positive evidence, at least on comparative examination results, to suggest that self-pacing is an essential ingredient of PSI.

These, however, may not be important findings. First, because the final examination criteria for performance is not necessarily a good test of student achievement; for instance, because PSI teaches for mastery not for some lesser achievement. Second, because much of the benefit of self-pacing may be related to student attitudes, reinforcement, and other factors not measured by a final examination.

One question could be asked: Is there a proportion of students who could only master the topics via PSI? The answer to this question is probably no, but innumerable researchers have found from survey questionnaires of students that they regard self-pacing as a very important part of PSI. (For example, Donovan and Northcott, 1974; Green, 1971; Kulik *et al*, 1974; Nelson and Scott, 1974.)

The other major research thrust in the area of

self-pacing came from the perceived problems of student procrastination and withdrawal, evident in early PSI reports. (Keller, 1968; Green, 1971)

Instructors have basically taken two approaches to minimizing procrastination. Firstly, by imposing deadlines and, secondly, "through the provision of prompts and/or positive reinforcements contingent upon constant or high rates of course progress" (Robin, 1976). The first of these falls into a comparison of teacher-paced versus self-paced groups dealt with above, and shows no significant differences in achievement between the two groups. However, other studies showed that deadlines increase the rate of tests taken (Robin and Graham, 1974), and the imposed deadlines cause earlier completion of units (Semb, 1974).

Positive incentive systems were found to effectively produce steady, evenly distributed rates of unit completion (Burt, 1975) and to combat procrastination (Green, 1971; Hess, 1974). More detailed discussions of self-pacing will be left to a later chapter. This will particularly deal with student attitudes and problems generated by self-pacing, such as procrastination and withdrawal.

2.3.2 *Mastery oriented*

In reviewing the research on the mastery aspect of PSI Kulik, Kulik and Smith (1976) reported that all reported studies demonstrated that the unit-mastery

requirement was a key feature of the system. For example, Semb (1974) points to the importance of a strict mastery requirement in PSI. Two groups of students taking a PSI child development course used passing criteria of of 100 per cent and 60 per cent. Those in the 100 per cent group did much better on a final examination. In another study students in a group who had the opportunity to repeat unit tests until they could demonstrate 100 per cent mastery did better on a final examination than a control group who were not allowed to repeat tests, and who received a final grade as a number of points obtained from tests (Phillips and Semb, 1976).

Davis (1975) put groups with low and high grade point average students into 100 per cent and 50 per cent mastery criteria. He found that 100 per cent mastery amongst both types of students resulted in higher achievement on final examinations; and that low grade point average students began studying earlier in the semester and studied more consistently under 100 per cent mastery than under 50 per cent mastery.

Robin (1976) in his more general study of behavioral instruction, concludes from his review of four research studies dealing with mastery requirement that they "demonstrate that the unit-perfection requirement contributes significantly to behavioral instruction" [p.343] , at least as far as achievement on final examination was concerned.

Again these results in favour of mastery as an

essential component of PSI must be considered in the light of whether final examination results are an appropriate distinguishing criteria of student achievement and the other benefits of PSI.

Imposing mastery criteria in PSI does also pose problems. In breaking the material down into discrete segments and closely specifying objectives a close check must be made so that the material does not become fragmented or disjointed. It is possible too that in a PSI system the students will become overloaded with work if the mastery criteria are set too high. This, of course, would also making passing unit tests more difficult thus reducing the beneficial effects of constant, positive reinforcement. Lastly, there are institutional problems. Self-paced, mastery can increase the number of students passing and offer results in a higher grade distribution than in conventional courses. This can pose problems with an institution. Furthermore, the need to demonstrate mastery continuously in PSI can change the student's study habits and affect his performance in other subjects. A challenge, therefore, is to manage PSI appropriately to minimize these problems.

2.3.3 *Student proctors*

Proctors mark unit tests immediately they are finished and in the presence of the student. The proctor can then probe the student's comprehension of the test

material. The proctor provides frequent rewards to the learner in the form of a sense of achievement and approval and does so in a non-threatening way. Threat of failure is greatly reduced by eliminating penalty for failure (Keller, 1968; Sherman, 1974).

In terms of contingent reinforcement, therefore, the proctors are providing fairly continuous rewards for the desired behavior of mastery of unit objectives as demonstrated by successful completion of a test.

As one proctor reports: "Immediate feedback is given and the whole interview is something like personal tutoring, which is a luxury in any class ... if one walked into a room where this method of teaching was used, most likely one would hear the constant hum of learning going on" (Ensign *et al*, 1971). Nevertheless, it should also be mentioned, as many reports testify, the proctors also gain much from the experience. Proctors may be recruited from later year students or may be what is termed "bootstrap tutors", i.e. the quicker students are set to assist their slower class-mates. Roper (1974) reports in favourable terms of his experience in using bootstrap proctors. In using later year students it is convenient if one can draw on students who have already done a PSI course.

The proctor's understanding of the subject is somewhere between that of the instructor and of the students. Thus the proctor can facilitate communication between instructor and student and in the process

establish a close relationship with the student. Such close relationships enable the students to see themselves being treated as individuals within the PSI framework and to enhance the rewards given by proctors for desired student behavior (Sherman, 1974).

Robin (1976) in considering research on the student proctor function in various types of behavioral instruction concluded from an investigation of 14 studies that proctoring contributes to the effectiveness of the instruction. Robin looked at proctoring in relation to four aspects and reported:

> that (a) proctoring increases student achievement and rate of course completion; (b) the feedback and social behaviors emitted by the proctor differentially shape student performance in ways yet to be definitely determined; (c) specific role-playing and feedback appear to be a promising approach to proctor training; and (d) internal proctoring produces comparable student performance to external proctoring but also benefits the proctors academically. [p.337]

However, the research on the proctor function specific to PSI is not so conclusive. Blackburn, Semb and Hopkins (1975) found that self-graded students performed as well on a final examination as proctor-graded students. Two other studies found that immediate proctor feedback on tests was more effective than delayed written feedback (Farmer, Lachter, Blanstein, and Cole (1972). Johnson and Sulzer-Azaroff, 1975). Perhaps this result can, however, be attributable to the delay in feedback rather than to the proctors. Indeed, Kulik, Kulik and Smith (1976) in their review of research on PSI reported that "there

is no good evidence that a proctor makes a distinct contribution to PSI's educational effectiveness" [p. 26]. This appears to be at odds with Robin's finding and illustrates an important point. Published reports often do not make it clear how their so-called PSI courses actually relate to the PSI of Keller (1968). Hence generalizations made about PSI must be treated with reservations because the courses considered might differ radically from Keller's original scheme. Alternatively, of course, some variations from PSI may not be critical. How this conflict may be resolved is, in fact, one of the main purposes of this thesis and will be treated in detail in following chapters.

2.3.4 *Written and oral communication*

Keller (1968) regards both written communication and social interaction as important aspects of his method. They are important because of immediate feedback of test results; because of clear specification of objectives and learning alternatives in study guides; and because of the interpersonal relationships that can be promoted by oral communication.

Calhoun (1975) studies six groups of students from one PSI course. Four of these received immediate feedback, and for the other two feedback was delayed until the next class period. As measured by final examination performance the four groups having instant feedback performed significantly better than the two groups with

delayed feedback. Similar conclusions were reached by Farmer *et al.* (1972) and Johnson and Sulzer-Azaroff (1974).

Semb, Hopkins and Hursh (1973) found that student performance on unit tests was better when the questions were related directly to study guides than not. Peters (1975) introduced pre-test monitoring by proctors in order to see if students had completed self-tests given in study guides. He found that this reduced the number of tests failed and caused more rapid course completion. Perhaps this indicates that properly managed, study objectives do contribute to achievement.

Robin (1976) in his more generalized review of behavioral instruction considered the stress on the written word in a narrower light. He was concerned to compare the effect of oral and written tests on student performance. He found that while students had a preference for oral tests, both types of testing produce equal achievement as measured on final examinations.

2.3.5 *Motivational lectures*

In PSI, as devised by Keller (1968) and his associates, lectures were not compulsory and were used as part of the reward system. Students who had successfully completed a certain number of units by a due date became entitled to attend a lecture. Excursions, demonstrations, and audio-visual presentations may be used in the same way.

There is some evidence to suggest that students are often more motivated by the need to qualify in order to attend, rather than the reward of the lecture itself (Boud and Nuttall, 1973). Such findings cast doubt on the value of lectures, at least as perceived by students (Startup, 1972). This finding is also supported by more objective data. Calhoun (1975) obtained comparable final examination performance from a PSI section with required weekly lectures and a control group who did not take lectures. Minke and Carlson (1973) found that adding lectures to a PSI course did not change any aspect of course performance. Furthermore, Robin (1976), in his review on the importance of lecture presentations reported only negative findings.

2.3.6 *Summary*

There is research evidence that mastery and written and oral communication contribute to the effectiveness of PSI. The evidence for self-pacing, student proctors, and optional lectures is not conclusive. Doubt is expressed whether final examinations are suitable and/or relevant measures of student achievement. This point is developed further in 2.6 as part of the rationale for this present research.

2.4 *PSI in Chemistry Teaching*

The review has so far been concerned with articles relevant to the overall methodology and application of PSI.

It is perhaps appropriate at this stage to consider the literature on PSI specifically related to chemistry teaching. There have been reports, Bibeau (1970), De Rose (1970), on the use of PSI in high school chemistry teaching but the majority of reports are related to tertiary chemistry studies. Of these, most have reported on the use of some modified PSI course in specific subject areas. Invariably any research studies have been confined to attitudinal surveys of comparative performance tests. Most of the reported users of PSI in chemistry teaching have evaluated their projects by the use of student questionnaires. In a report on the Proceedings of a Symposium of Self-paced Instruction in Chemistry (Shakhashire, 1973) eight authors report that student attitudes towards PSI are more favourable than towards conventional courses. These findings are repeated by individual reports such as Leo (1973), Donovan and Northcott (1974), Hendrick (1975), Kissling (1973), and Cunningham and Moore (1973). In several of the above reports studies have been carried out on PSI versus lecture format on final examination results. Their results confirm other more general findings that results of PSI groups are equal or better than conventional groups in all reported cases, at least so far as performance measured by final examinations are concerned.

Two studies report on more closely controlled experiments. Lewis and Wolf (1973) implemented a PSI course in freshman chemistry. Their PSI was modified from Keller (1968) in that the mastery requirement was 85 per cent and the associated laboratory course was not self-paced. Of a final group of

19 students taking the PSI course in one semester, 17 successfully completed the units and 15 of these elected to take the final examination. For these 15 the average on the final examination was a statistically significant 17.5 percentage points higher than the average for the rest of the 140 students taking the normal course. In the second semester, 70 students took the course by PSI, 50 by the conventional method. The final examination was an ACS General Chemistry Test, Form 1970 - a series of multiple choice questions standardized nationally. The PSI student group averaged 26.7 against the national median mark of 18.4. Their average mark on the course examination, however, was not statistically different to the conventional group.

In a study of student attitudes to the Keller Plan, Silberman and Parker (1974) measured seven student variables of a class. Some students took a PSI course and others a conventional course in organic chemistry. Post-course achievement was measured on a final examination based on standard ACS tests. The seven variables measured, selected because of the authors' perception of the Keller Plan, were: reading and comprehension and speed; general chemistry grade point average; and four personality factors of responsibility, sociability, ascendancy, and emotional stability. Correlation of these with final examination results produced only two statistically significant results. For the conventional course past grade point average correlated at $r = 0.69$ ($\sigma = 0.05$) with the result. For the reading comprehension variable the correlation for the PSI group was only significant

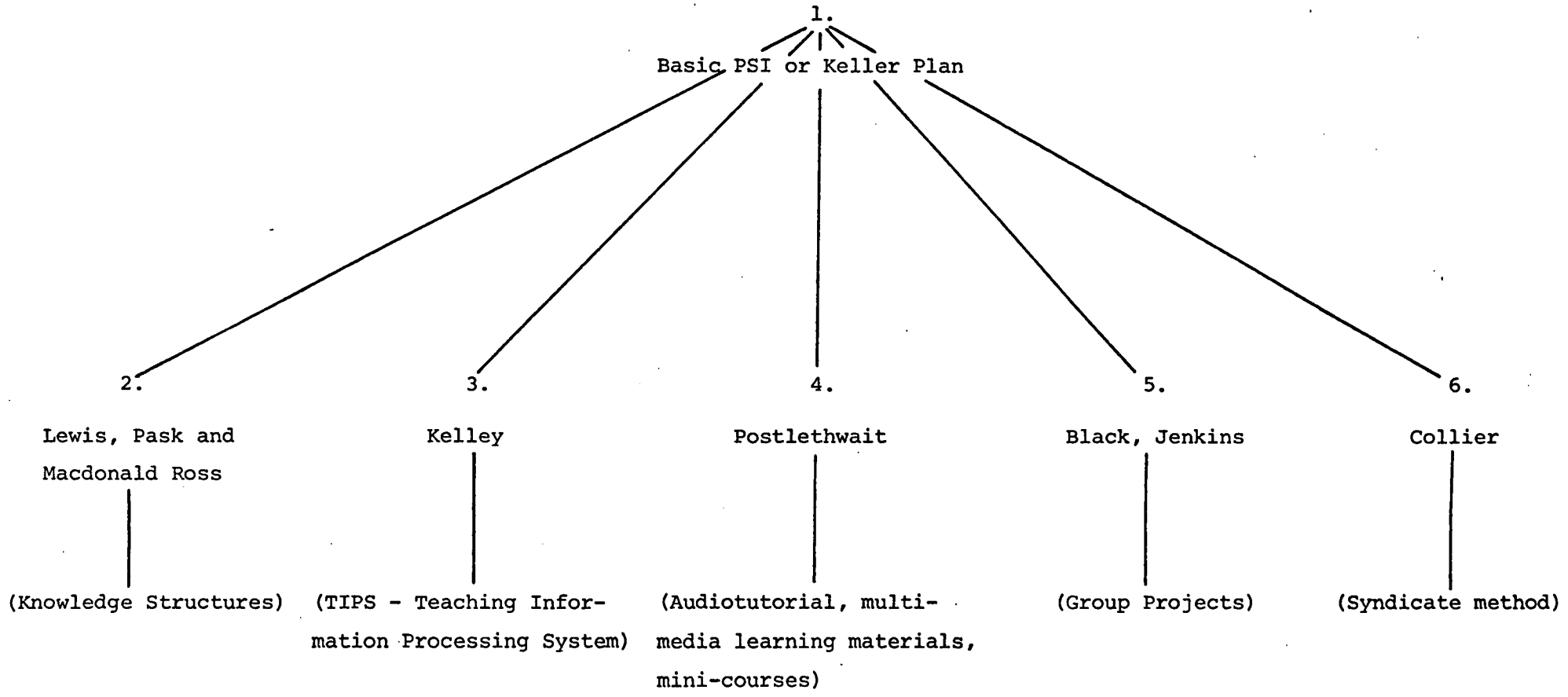


Fig. 5 Modified PSI incorporating extra components -

A developmental and experimental design

at the 0.08 level.

Summary

PSI has been used in a few high school and tertiary chemistry courses. Authors report favourable student attitudes towards PSI courses. Only two non-attitudinal research studies on PSI chemistry courses have been reported and these showed no significant results.

2.5 *PSI in Relation to some other Tertiary Teaching Methods*

PSI has its roots in reinforcement theory and its genesis in programmed instruction. Keller (1968) noted how his method had characteristics in common with other innovations. In the context of current tertiary education practices, several other teaching methods share common ground with PSI. Figure 5 illustrates how additional components could be compared within the PSI scheme (Donovan and Northcott, 1974). Some brief illustrative quotations of some of these other methods and referencing of sources are given below.

2.5.1 *D.E.P. Jenkins writing on Group Projects in Engineering (1971)*

> University lecturers by and large are very traditional in their outlook and, for various sound educational reasons, often find it difficult to move away from the well tried University pattern of educating with its established method of examining. It is always surprising how quickly young, new University lecturers take on the shape of this mould, with its built in resistance to change. Changing the pattern of educating from a teaching pattern to a learning pattern is a difficult one since the role of the lecturer has to change, the role of the student changes, the method of transfer of information changes

and with this, the method of assessment; in practice all this happens simultaneously and it exposes the lecturer to a situation where his points of reference are continually shifting and the lecture (where he has almost unchallenged autonomy and superiority) may well lose its predominence in the system. [p.38]

2.5.2 *P.J. Black, N.A. Dyson and D.A. O'Connor on Group Studies in Physics (1968)*

The main accent in university courses is on understanding theory and it is much more difficult to learn several theories at once in the hope that any or all of them might one day be useful, than to study a particular topic because one knows that a specific problem on one's bench or in one's notebook cannot be understood without it. This problem of motivation is made more serious by an examination system which places most weight on performance in a set of written papers taken within a period of a few days at the end of the course. It is easy to work effectively when there is a need for immediate results on a specific topic, and such effort is rewarded and further stimulated when a part of a task is known to be completed and can be laid aside. A student's task is more difficult because for most of his course, the preparation is for a far-off date and because most of his effort cannot be rewarded and laid aside until the last week of his work. [p.289]

2.5.3 *K.G. Collier on the Syndicate Method (1966)*

One of the major problems of higher education ... is that of weaning the student from dependence on instruction and building up his powers of critical judgment. The Hale Report put it thus: 'The aim ... of the undergraduate course ... should not be only or even primarily to equip the student with knowledge, but also, and more importantly, to teach him to think for himself and work on his own ...'

As I see it, one effect of several years of largely authoritarian instruction between the ages of 10 and 16 is to establish in students' minds not only an assumption that education is the imparting of information and techniques to pupils, but also certain attitudes which make

> it difficult for both students and lecturer to escape from the habits of instruction and memorization ....
>
> It is of some urgency that more systematic and scientifically assessed experimentation should be conducted in teaching methods. [p.431]

A substantial case appears to have been made for considering PSI as an appropriate method of conducting subjects or sections of subjects where serious content has to be mastered in detail. In Green's (1971) phraseology: "Where there are specific things to learn" [p.81]. However, with such a complex matter as the teaching-learning process it would be foolish to suggest that PSI is a panacea. As with all teaching methods it is important to discover what learning objectives it can achieve with advantage and include it for these reasons perhaps within one's repertoire of teaching techniques.

Keller's (1973) more recent comments are a valuable summary of the status of PSI at present: "I am somewhat more sanguine about the future than I was. This in spite of the fact that our plan is mis-used more often than it is used correctly. I think we have just begun" [p.2].

2.6 *Rationale for the present Research*

In 1973 when the PSI Chemistry I course and the research described in this thesis were being planned, the literature on PSI was just developing. Subsequently reviews of the early years of PSI (Pennington, 1973; Ryan, 1974; Kulik,

Kulik and Carmichael, 1974; and Hooper, 1974), of the research literature on PSI (Kulik, Kulik and Smith, 1976) and of the more general review of behavioral instruction (Robin, 1976) have appeared. These reviews have demonstrated that PSI is an effective instruction technique, at least as measured by student performance on final examinations and by comparison to other methods. They have also demonstrated, in the main, favourable student attitudes towards PSI that could only be helpful in transferring positive attitudes to the subjects being studied in this way.

In an Australian context, Donovan and Northcott (1974) reported favourable student attitudes towards a PSI pilot course in chemistry; and Eley (1976) found that his students completed a PSI educational psychology course "with a positive affective reaction to both course content and the PSI strategy" p.70 .

Further, Robin's (1976) review of behavioral instruction tends to confirm the central role and essential value of frequent testing, proctoring, mastery, and study objectives to such instructional methodologies. On the other hand, his findings suggest that self-pacing and optional lectures may not be necessary for effective behavioral instruction.

It is perhaps not surprising, therefore, that some of the original aims behind this present research project have been fulfilled, at least in part by other researchers. Such aims as demonstrating the effectiveness of PSI and the necessity of retaining its component parts fall into this category. There still remains, however, two major aims of

this research that have remained largely untouched. The first of these pertains to the style of course evaluation developed and implemented in this study. In this context, most course evaluations reported on PSI have been confined to fragmentary approaches. Examples of this are: the use of attitudinal surveys in several cases; subjective judgments of participants; analysis of course records; and, most frequently, the attempted use of a control group, pre-test, post-test study on one or more of the features of PSI taken in isolation from the evaluation of the whole course.

An attempt has been made, therefore, in the research reported herein to construct a course evaluation model based on current approaches in this area and to evaluate the Chemistry I course using this model. The reasons for this different approach are two-fold. First, other instructors could learn from this example in making their own course evaluations. Such a generalized course evaluation gives them a more coherent set of information on which to judge PSI, at least in chemistry teaching.

Second, using this course evaluation strategy, it is also possible to focus on some major issues that still remain unresolved. For instance, Robin (1976), in discussing future directions of research into behavioral instruction courses, suggests that persistently high drop-out rates from such courses is against the philosophy of attention to the needs of individual students and must be subjected to further investigation and remedial action.

In a review of the early literature on PSI, Ryan (1974)

was concerned that the then novel PSI method could perhaps fade from the educational scene going the way of many other innovations. He suggested that instructors wishing to run PSI courses should be well versed in basic behavior theory so that they could successfully manage their courses to fit particular circumstances. His concern for effective management of PSI courses has been shared by Pennington (1973), Donovan and Northcott (1976), Green (1973), Sherman (1974), and others.

With respect to student performance criteria most researchers have concentrated on results from final examinations. As already noted above, there is some doubt as to the appropriateness of such criteria, and there needs to be further attention paid to developing and examining other criteria.

Allen, Giat and Cherney (1974) have investigated the effects of locus of control and trait test anxiety on final grades and other academic outcomes for students in a Keller-type history course. They concluded that students with external locus of control performed significantly worse than their more internally oriented peers. No reliable relationship between trait test anxiety and academic outcomes was found, but their results did suggest that compared to traditional examination courses the Keller-style course reduced the anxiety of students during the course. Allen *et al* further concluded that teaching methods should be tailored to the characteristics of individuals as different forms of teaching are not equally effective with all students.

Goldberg (1972) carried out a large scale control-group study to determine those personality characteristics of students which predispose them towards learning more effectively from one, rather than from other, particular instructional format. In this search for trait-by-treatment interaction effects he was unsuccessful. He postulated that this lack of difference between teaching methods could have been due to crude criterion measures, to poor instructional methodology or that tertiary instruction is a more complicated research area than he had initially assumed.

Goldberg used the traditional lecture/seminar format and self study as the teaching methods and examinations via multiple-choice questions or integrated papers to provide four "different" instructional techniques in his research design. The critical thing that was constant for all Goldberg's groups was the complete specification of course content and final assessment requirements. Thus his findings could also imply that with tertiary students, so long as they know exactly what is required of them teaching methods *per se* may be relatively unimportant. Given the strong emphasis in PSI on the clear specification of performance objectives to the students, Goldberg's findings could then be interpreted as supporting PSI as an appropriate strategy for tertiary-level teaching.

With students entering tertiary institutions from diverse backgrounds and widely differing age groups, systems like PSI could provide a suitable educational system in which to provide individualized programs to suit students' needs. In this regard

it would be useful to categorise students who could successfully handle a PSI course, say as compared with those who can successfully cope with a lecture-final examination system.

Robin (1976) also discussed the possibility of extending such research on how student characteristics interact with components of behavioral instruction and recommended this as a needed area of research. There are, of course, other areas of PSI that need to be the subject of research but the four issues of procrastination, effective management, student performance criteria, and of whether PSI is more suited to students of certain personality characteristics than others have been chosen as issues on which to focus in the research described in the following chapters.

CHAPTER III

RESEARCH STRATEGY

Course evaluation should be considered an integral part of any tertiary instructor's responsibility as an educator. Boud (1977), for example, sees evaluation as a means of enhancing the professional role of the instructor; that is, the instructor becomes an extended professional rather than a restricted professional.

In this regard Hoyle's (1972) descriptions of school teachers could well apply also in the tertiary area. He describes the restricted professional as one who has:

> a high level of classroom competence;
> child-centredness (or sometimes subject-centredness);
> a high degree of skill in understanding and handling children;
> derives high satisfaction from personal relationships with pupils;
> evaluates performance in terms of his own perceptions of changes in pupil behaviour and achievement;
> attends short courses of pratical value. [p.143]

The extended professional on the other hand is one who:

> views his work in the wider context of school, community and society;
> participates in a wide range of professional activities, e.g. subject panels, teachers' centres, conferences;
> has a concern to link theory and practice;
> has a commitment to some form of curriculum theory and mode of evaluation. [pp.143-144]

This definition of the extended professional is too limited for Stenhouse (1974) who adds further crucial characteristics:

> The commitment to systematic questioning of one's own teaching as a basis for development;
> The commitment and skills to study one's own teaching;

> The concern to question and to test theory in practice by the use of these skills. [p.144]

Stenhouse states that "the outstanding characteristics of the extended professional is a capacity for autonomous professional self-development through systematic self-study, through the study of the work of other teachers and through the testing of ideas by classroom research procedures" [p.144].

Applying this to tertiary instructors it would be expected that the full professional is one who:

i) sets his own goals;

ii) determines his resources;

iii) plans his program;

iv) engages in self-evaluation.

However, there seem very few examples in the tertiary science education literature in which formal evaluations were carried out by instructors. Where evaluations are reported they are usually of innovations. For instance in the PSI area, Born, Gledhill and Davis (1972), Kulik, Kulik and Carmichael (1974), and others demonstrated under controlled conditions that students in PSI courses learned as well if not better than those in conventional courses. Again, Leo (1973) and Cassidy *et al* (1973) used the survey questionnaire approach with students in PSI chemistry courses to show favourable attitudes towards these courses.

There seem two main reasons why tertiary science instructors are not formally evaluating their courses. First, most such instructors are not trained as teachers but rather as subject specialists. Hence they are probably unaware of the principles of educational psychology and of course

evaluation procedures. Second, evaluation may appear to be a specialist art, and the language and jargon of evaluators might put off instructors without educational training.

One purpose of the research described in this thesis was to evolve an evaluation strategy suited to self-evaluation by the instructor and to test the use of this strategy on the PSI Chemistry I course. This may provide other tertiary science instructors with a possible model for evaluation of their courses. A second purpose related to the need to evaluate change, in the case the use of an innovatory teaching style, PSI, in the Chemistry I course. Bridge (1975) considers it important to evaluate change for three reasons:

i) In a new course students and teachers are often unaware of the roles they should adopt and of the procedures that will be necessary. To resolve these uncertainties is one of the functions of evaluation.

ii) The courses, while often including material that is tentative and flexible, have also the potential to produce a lot of information about the teaching/learning situation.

iii) Innovatory courses are hard work, at least for the teachers and often for all others involved. It is important, therefore, to establish whether the courses are worthwhile, what problems are involved and whether and how the courses can be improved.

Having decided, therefore, to evaluate the PSI Chemistry I course the procedure was carried out in five stages:

a) Deciding on the aims of the evaluation.

b) Selecting the necessary research methodology to achieve these aims.

c) Putting the research program into operation.

d) Analysing the results.

e) Taking action or suggesting action on the basis of these results.

The first three parts of this strategy are described in this chapter and the latter two in succeeding chapters.

3.1 *Aims of the Evaluation*

Educational evaluation can broadly be divided into two categories:

i) Formative : where the aim is to provide detailed feedback information about the materials and methods of the course, in order that it may be improved as it goes along.

ii) Summative : which takes a more overall view of the course. Its purpose is not necessarily to improve the course, but to judge it, either by some absolute criteria such as its achievement of a list of learning objectives, or by means of a comparison with other teaching methods.

In many cases, of course, the two types of evaluation become inextricably mixed. For instance, in determining the success or otherwise of a particular innovation, it may well be that information obtained during the evaluation is taken into account in improving the course for future operation.

The aims of this evaluation were to:

1. design and implement a self-evaluation strategy that might be used by other instructors;
2. formatively evaluate the introduction of PSI into a Chemistry I course, so as to implement successfully this innovation;
3. describe and understand the working of the PSI courses and the people in them;
4. provide information needed by teachers and administrators about PSI, in order that they may make judgments about them;
5. focus on and resolve issues such as appropriate student performance criteria, procrastination, effective management, and personality versus student performance in PSI.

Having decided on these aims the next stage was to select the appropriate research methodology to achieve these aims.

3.2 *Educational Research Methodology*

The switch of terminology from evaluation to research is deliberate. The term evaluation, as used in this thesis context, can be defined as providing information on which to make decisions.

The strategy by which course evaluation is carried out can best be described as educational research. This will become clear as the methodologies considered for the evaluation are discussed. Traditionally, a major aim of course evaluation research has been to show that students in,

say, an innovatory course learn better or differently than a control group of similar students in another teaching-learning situation. This experimental-control methodology has been described by Parlett and Hamilton (1972) as the agricultural-botany model, in that it relies on the use of the pre-test, post-test, control group format which allows a rigourous assessment of causal relationships and performance comparisons. This type of research is most often carried out by external evaluators.

Recent British reports, however, suggest that this research methodology, taken in isolation, is not necessarily appropriate when applied to many formative aspects of educational practice. Parlett and Hamilton (1972) identified some of the difficulties which arise:

1. Attempts to define relevant educational parameters before formal evaluation produce artificial situations divorced from reality because these parameters are effected by the educational process.
2. The need to randomize these parameters requires large samples or strictly controlled groups and these are usually not available before an innovation is introduced in the tertiary area.
3. Before-and-after research designs are ineffective in design and development stages of innovations because they may constrain the innovator from taking account of changed circumstances that may arise.
4. The need to produce objective results from quantifiable data unnecessarily restricts the

innovator, in that much of what is subjective can often be more useful in making changes as he goes along.

5. Similarly, atypical and unusual results often are neglected in making statistical generalizations, yet these results could be vitally important in a localized situation.

6. Traditional evaluations tend to produce reports which are couched in terms of objective truth relevant to all parties but rarely deal with questions posed by different interest groups.

In a similar vein, but in a North American context, Kemmis (1974) sees three major shortcomings of the agricultural-botany model which he terms "the preordinate approach" [p.3], to be:

a) its emphasis on student achievement outcomes over other intended and unintended outcomes;

b) its use of experimental designs more appropriate to pure research settings rather than to real situations;

c) its preference for behavioral objectives and a tendency to limit the evaluation by their use.

There is obviously then a close similarity of the objections of Parlett and Hamilton, and those of Kemmis to the traditional evaluation model.

In the PSI context it is interesting to note the comments by Robin (1976) after reviewing the research into behavioral instruction in the college classroom. Robin was

critical of most of the individual research reports mainly on technical grounds and, at the end of his paper, states that:

> The methodology of outcome studies must be improved. In addition to the more stringent use of experimental controls for traditional between group comparisons ... it would greatly enhance the generalizability of outcome evaluations if investigators would routinely compare methods across several courses and replicate findings across several semesters. [p.343]

In most cases these recommendations, if followed, would be extremely difficult to implement. For example, staff changes, different pupils, changes to course structures and teaching strategies would be desirable, if not inevitable, for course improvement, thus making control of variables extremely difficult. Secondly, of course, many educational institutions are simply not large or diverse enough to allow for the research techniques he suggests.

There seems, however, merit in Robin's own approach. If findings are replicated across various experimental studies then he accepts them subject to an analysis of the research techniques employed. Thus results not acceptable in a one-off study can be verified by other researchers in other areas. These types of findings then take several years to develop and are, therefore, of little immediate help to the teacher-researcher in his own course design and evaluation.

That is not to say that all such "hard-nosed" research is irrelevant - that is not so. There will frequently arise issues which can best be resolved by objective proof of a particular hypothesis. Indeed the experimental-control model was used for the investigation of the relationship between students' personality and their performance in PSI

and a more traditionally taught Biology I course, described later in this chapter.

What is being said by many authors is that the traditional approach in its search for objective and statistically significant measures is not, of itself, entirely appropriate for evaluating the complex human situation which exists in an institution in which an innovatory course has been introduced.

This is particularly so in the area of self-evaluation. A new style of evaluation has been emerging in Britain which Parlett (1974) terms the illuminative approach. This technique has its roots in anthropology and sociology rather than in experimental psychology and has much in common with the responsive evaluation of Stake (1973) in the American context. According to Parlett (1974) illuminative evaluation is an "intensive study of the program as a whole: its rationale and evolutions; its operations, achievements and difficulties" [p.15]. The methodological strategies of observation, interviews with participants, questionnaires, and analysis of documents and background information all combine to help "illuminate" problems, issues, and significant program features.

Two basic operations of illuminative evaluation can be identified. The first of these is focusing. Some problem, disagreement or question is raised by, say, a questionnaire response or an interview. The researcher then focuses attention on this point to elaborate on it, to verify it, to deny it, or merely to put it into a wider context. The

basis for action is usually obtained from the second process, sometimes called triangulation. This entails looking at a particular issue from several different directions. For instance, it may be that student comments on a questionnaire suggest that a particular unit of work is too difficult. This could be checked, for instance, by interviews, from the course records, and from observation. If confirmation is obtained from all directions then something can be done about restructuring the unit of study.

Parlett and Hamilton (1972) describe the major characteristics of illuminative evaluation as follows:

i) It is collaborative, it brings together as many people as possible as active participants to describe and interpret the system under observation.

ii) It is based in the teaching-learning situation, that is, in the world of reality rather than of theory.

iii) It is client-centred.

iv) The research theories and methods are multi-access and the results are made as comprehensive as possible to clients and readers.

v) As many methods are used as possible to check on the validity of judgments of the researchers.

Stake (1973) in talking about his own style of responsive evaluation, had this to say:

> An educational evaluation is responsive evaluation (1) if it orients more directly to program activities than to program intents, (2) if it responds to audience requirements

> for information, and (3) if the different value-perspectives present are referred to in reporting the success and failure of the program. In these three separate ways an evaluation plan can be responsive. [p.3]

It can clearly be seen that illuminative and responsive evaluations have much in common, and this general style of evaluation will be called illuminative evaluation in the remainder of this thesis.

Stenhouse (1974) and Parsons (1976) in commenting on the new illuminative evaluation of Parlett and Hamilton both make the point that this style of evaluation is really a form of educational research or a start in this direction. Stenhouse (1974) traces the links between the various 'new-wave' evaluators in reviewing the holistic approach (MacDonald), illuminative evaluation (Parlett and Hamilton), portrayal and responsive evaluation (Stake), and transactional evaluation (Ripley *et al*). In discussing these he had this to say:

> The new wave of evaluators still seem to me to concerned with 'merit' or 'worth' in a curriculum or educational practice, but their criteria are not clear and their concern with audiences and presentation of results appears to me to mask their problem. They aspire to 'tell it as it is', and they often write as if that is possible if they allow for some distortions on the way. But there is no telling it as it is. There is only a creation of meaning through the use of criteria and conceptual frameworks. The task of briefing decision makers in language they readily understand can too easily lead to the casual importation of unexamined assumptions and criteria. Audience response can be seductive, especially if the audience is politically powerful. And it is too easy for the evaluation which aspires to the condition of the novel to degenerate into the novelette. [p.116].

Stenhouse goes on to develop five criteria which might be used in curriculum evaluation:

i) Meaning : in which a philosophical critique is used to disclose the meaning of curriculum rather than to assess its worth.

ii) Potential : to decide the potential of the curriculum for what, and can it be achieved.

iii) Interest : to determine the problems a curriculum raises in practice.

iv) Conditionality : to relate potential and interest of a curriculum in the context of a school or classroom.

v) Elucidation : to determine if the introduction of an innovative curriculum clarifies the more general problems of change in education.

From this he postulates the extension of this to the development of a research model for curriculum evaluation and has this to say:

> We know enough now to shun the offer of ready solutions. Curriculum research must be concerned with the painstaking examination of possibilities and problems. Evaluation should, as it were, lead to development and be integrated with it. Then the conceptual distinction between development and evaluation is destroyed and the two merge as research. Curriculum research must itself be illuminative rather than recommendatory as in the earlier tradition of curriculum development. [p.122]

Parsons (1976) in sounding a cautionary note about the new illumination has this to say:

> In many ways, however, illuminative evaluation is not merely a style of evaluation, but fits more comfortably beneath the broader title of educational research. It recommends flexibility in method, and breadth and variety of data sources, aiming for description and interpretation, and a comprehensive understanding. [p.127]

Parsons also takes the proponents of illuminative evaluation to task for failing to integrate their approach with much earlier work of sociological case study approaches designed by sociological researchers. To quote Parsons (1976) again:

> Becker and Cicourel, in their investigation of facets of institutions, have marked out fairly rigourous standards:
> (1) for the collection and validation of data;
> (2) for hypothesis generation and testing;
> (3) for the construction of descriptive models and conceptual frameworks which best explain the assembled data;
> (4) for ways of displaying data to support conclusions, in order that others may judge the credibility of these. [p.129]

Of course, the writings of Stenhouse and Parsons were not available to the author when he initiated the course evaluation reported in this thesis. They do, however, support the contention made earlier that evaluation is a branch of research and should be treated as such.

The Chemistry I course evaluation strategy reported herein can be seen as a derivative of the illuminative style but specifically adapted to self-evaluation by the instructor.

3.3 *The Research Program*

The program needs to satisfy the twin purposes of this research, that is, to develop and test a suitable self-evaluation strategy and to focus on the major issues of student performance criteria, procrastination, effective management, and personality versus student performance. That being so, the research can be considered as covering five areas:

1. Course design and development;

2. Management;
3. Student performance;
4. Student attitudes;
5. The relationship between student personality and performance.

3.3.1 *Course design and development*

The formative evaluation of the PSI course, while permeating the whole evaluation, can be seen as of major importance in the design and development stages. Bridge (1975) proposed a framework of questions about self-study courses which appeared appropriate to use as a basis for this evaluation. This framework of questions has been modified and reduced in scope to suit the PSI Chemistry I course. The questions defining the issues involved in the design and development of the course were:

a) What problems were involved in the design of the course?

b) How enjoyable, easy to learn from, useful to the course were the following components of the study units:

   Objectives;

   Suggested procedure;

   Resources provided;

   Self-test questions?

c) Unit tests:

   Were the tests too difficult?

   Were the repeat tests for each unit of similar standard?

Was there a direct relationship between test items and unit objectives?

3.3.2 *Management*

The literature on PSI appeared to suggest that the management of the system was an important factor for efficient operation. The subjective assessment of this author during the trial stage of the project reinforced this view. This issue can be reduced to the following questions:

a) Learning centre conditions:

What was the rationale behind the development and use of a learning centre?

How do you design an appropriate learning centre?

Is there too much noise or crowding?

What is the availability of instructor and proctors for testing and tutoring?

What is the optimum arrangement of furniture?

What are the appropriate length and frequency of test sessions?

Does any form of cheating occur?

b) Proctors:

What do they actually do?

How and at what level do they mark tests?

What is the student reaction to being proctored by fellow students?

What degree of proctor/student contact exists? Is this valued?

What effect has proctoring on the proctors?

c) Materials:

What does the production of adequate course materials involve?

d) Security:

Does any form of cheating occur?

e) Costs:

What does the course cost:

a) In terms of man-hours;

b) Part-time assistance;

c) Proctors' fees;

d) By comparison to a conventional course?

How can a PSI course be run more efficiently?

Is it possible to transfer the use of such a course?

3.3.3 *Student performance*

Any innovative course and teaching method introduced should have a beneficial effect on student performance, i.e. it should help the student learn better and more efficiently. A major issue with PSI is undoubtedly that. The following questions raise the issues involved.

a) How did the students perform in the PSI Chemistry I course?

How does learning by this method compare with learning by other teaching methods?

b) Is procrastination a problem? If so, how can it be overcome?

c) Were the anti-procrastination measures successful?

3.3.4 *Student attitudes*

As discussed above (see Chapter II) many authors have reported favourable student attitudes towards their PSI courses. Is this so for this PSI Chemistry I course? The following questions delineate this issue.

a) Motivations:

Do the students feel there is adequate compulsion to work? Would they like more? What parts of the course make them keen to work? What parts of the course put them off? How is their interest in the subject matter affected by the course?

Is the course seen as a competitive or a co-operative venture, by slow and fast students?

Do the optional "stimulus" lectures have any effect on motivation?

b) Attitudes:

Development of attitudes towards: working on self-study material; self-pacing; really mastering material before progressing; tests and continuous feedback/assessment.

Do the students feel that the course is an efficient/enjoyable means of learning?

What attitudes towards the method and content of the course do the staff reveal?

c) Tests:

What are the students' reactions to tests, particularly:

i) apprehension,

ii) value or otherwise of feedback about learning,

iii) perceived level of mastery?

What actually happens during a test marking session?

What is the quality and quantity of feedback from students gathered during a test session about the course and the units?

d) Tutoring:

What is the role of the instructor in tutorial situations?

What are the students' reactions to tutoring?

What degree of staff/student/proctor contact exists and how is this valued?

3.3.5 *Personality and performance*

In looking at student performance in PSI courses several factors assume critical importance. The problems of failure, drop-out, and inability to cope with a different learning system, of the necessity of building up new personal relationships with staff and other students, of differing types of work loads and teaching

systems are some of these.

The problems of failure and drop-out from tertiary courses has been a source of concern for some time. In the context of a PSI course it is possible to identify such students at an early stage because of the mastery criterion required, the regular testing, and the abundant records kept. Appropriate counselling or remedial action can then be taken, either to assist the student or to redirect him to other areas of study or work.

It would possibly be more useful if information could be obtained about the students before they commenced a course to identify if they are possible candidates for withdrawal or failure, i.e. it would be useful to establish criteria which would indicate possible problem students.

From observations on the PSI system in operation it appeared that certain students could handle it easily while others were in extreme difficulty. Personality appears to play a big part in this, while such supposedly objective measures as science aptitude and previous chemistry results may be not as significant.

PSI is supposed to be an education system that allows for individual differences between students in that it allows students to study how and when they want to and to proceed at their own pace. Some questions that can be raised here are:

a) Is this really so? Does PSI allow equal opportunity to all students? Does PSI suit all

students? Are students of differing abilities equally suited to PSI?

b) Are personality factors to be considered against student performance in PSI courses?

In focusing on these five issues a number of research techniques were incorporated into the evaluation process of finding answers to the questions posed. These were:

Observation;

Feedback slips;

Analysis of course materials;

General course questionnaire;

Discussion/interviews by instructor;

Discussion/interviews by consultant;

Written comments;

Student records;

Proctors' questionnaire;

Pre-test, post-test experimental design.

How these were used in the overall context of the evaluation is described below.

3.4 *The Evaluation Strategies*

3.4.1 *Formative evaluation*

Within the design and development stages of a teaching innovation there is inevitably some formative evaluation carried out. Whether this is deliberate or not depends on the innovator. It would appear obvious, therefore, that it would be better to set up this

process on a formal basis.

A major problem, however, is that it is virtually impossible to separate formative evaluation from either the design or development stages or from the overall evaluation of the project. For instance, questionnaires which test student opinion can assist in restructuring a course as well as providing evidence for summative evaluation.

At this stage, therefore, discussion on formative evaluation will be confined to the processes which were specifically set up for this purpose.

3.4.2 *Feedback slips*

The first trial group of 15 students were asked to fill in feedback slips on each unit they successfully completed. These slips were handed out by the proctor, filled in anonymously by the student, placed in a reply box, retrieved from there and the results collated by an educational technologist. The feedback slip represented an easy, quick means of gathering data about the units of the course. A copy of the feedback slip is shown (see Figure 6). Information gained from these, from staff observation, and from student interviews were used to modify and redesign the structure, content, and mode of operation of the units, both as they were being constructed in 1974 and in the re-write done for the second run of the course in 1975.

discuss this readiness test with your proctor.

UNIT NUMBER -------- TEST NUMBER -------- DATE TAKEN --------
TESTS TAKEN FOR THIS UNIT: 1 2 3 4 (please circle)

HOW DO YOU RATE THIS UNIT ON THE SCALES BELOW?

Very interesting	_____	_____	_____	_____	_____	_____	_____	Very uninteresting
Very well organised and presented	_____	_____	_____	_____	_____	_____	_____	Very poorly organised and presented
Activities suggested were very helpful	_____	_____	_____	_____	_____	_____	_____	Activities suggested were very unhelpful
The test was very easy	_____	_____	_____	_____	_____	_____	_____	The test was very difficult

What did you like about this unit? COMMENT

What did you dislike about this unit? COMMENT

Any other comments? (Please include suggestions as to how you think the unit could be improved.)

Fig. 6 Unit comment sheet

3.4.3 *Attitudinal questionnaires*

A general course questionnaire was designed to test student reaction to the course. This questionnaire was trialled initially on the pilot group of 15 students who took the PSI course in 1974. As a result of this run and from feedback from the students, the questionnaire was modified for use in 1975.

The design and administration of the questionnaire was carried out by the Educational Practices Unit of the college in consultation with the instructor. It was distributed to the students who remained at the end of the General Chemistry course, i.e. in June, 1975. Twenty-three replies were received which represents a 79 per cent response.

A copy of the questionnaire incorporating an analysis of the students' replies is given (see Appendix 4).

3.4.4 *Discussion/interviews by instructor*

Many opportunities existed in the PSI system for discussion between students and instructor/researcher. These were not formalized in any way and usually took place around the coffee urn or in the laboratory. Much of the information gathered in such sessions was used in conjunction with feedback slips and the course questionnaire in the development of course materials and the operation of the PSI system. Despite the lack of formalization such discussion and interviews are useful

evaluation tools. This part of the evaluation would have been enhanced if the researcher had kept a detailed set of notes on each session.

3.4.5 *Discussion/interviews by educational technologist*

The researcher made use of the Head of the college's Educational Practices Unit to contribute in both an informal and formal manner to the evaluation. The technologist recorded three formal interviews all on colour videotape. The first of these was with the instructor and consisted of a structured set of questions and answers taking the instructor through his experiences with the PSI system. The second was an interview with the first three student proctors on the Chemistry I course, discussing with them their reactions to proctoring and to the PSI system. The last recording was with the first proctor who later became administrative assistant to the instructor.

3.4.6 *Written comments*

Many people involved in the PSI course have been asked to make written submissions to the evaluation procedure. These range from proctors' essays, proctors' and students' private logs, instructor's essay and papers on the topic, technologist's writings on the PSI Chemistry I system and written comments from other staff in the college.

3.4.7 *Student progress data*

One of the features of the PSI system is its information handling capacity. Records can easily be gathered about all aspects of the course. It is important to record the information gathered in easily accessible form. As far as the students' records are concerned, these are handled in three ways. Firstly, a file is kept for each student in which all his tests are kept and in which there is recorded his results in these tests and general progress information. Secondly, a class chart is kept showing the progress of all students in the course. Thirdly, graphs are plotted for each student. These show at a glance the rate of progress of the student and the number of tests taken per unit.

3.4.8 *Record keeping*

As well as students' records there are other records which are available to assist in evaluation. Some of these are: details of financial expenditure and commitments, academic board minutes, examination records, correspondence of the instructor/researcher, as well as drafts and rewritings of course materials, course proposals, and submissions.

3.4.9 *Questionnaire on proctors*

With the consent of the proctors concerned, the Educational Practices Unit asked the students to rate

their proctors in relation to attributes considered by the instructors to be desirable in a proctor. A copy of the questionnaire is given (see Appendix 5).

3.4.10 *Experimental-control study*

To investigate the questions posed in 3.3.5 above a pre-test, post-test research design was constructed (see Figure 7).

There were 31 students in the 1975 Chemistry I class. Of these twenty-three were also taking Biology I. A further group of 15 students taking Biology I, but not Chemistry I, were also used in the study. Two further student groups were also considered. Firstly the Chemistry I PSI class at the northern campus of the college, 140 miles away. Secondly, the Physics I class of the college. This latter was run also on a PSI system but somewhat differently from Chemistry I. There were no student proctors; staff carried out that function. Also there were no review units and tests on the units were of approximately one hour duration compared to the 20 minutes in Chemistry I. Further, the associated practical course was not self-paced. Biology I was taught through a conventional lecture, tutorial system with some project work as extra student activity. Assessment in Biology I was essentially on a final examination with 20 per cent contributed from a practical mark.

At the commencement of the semester an

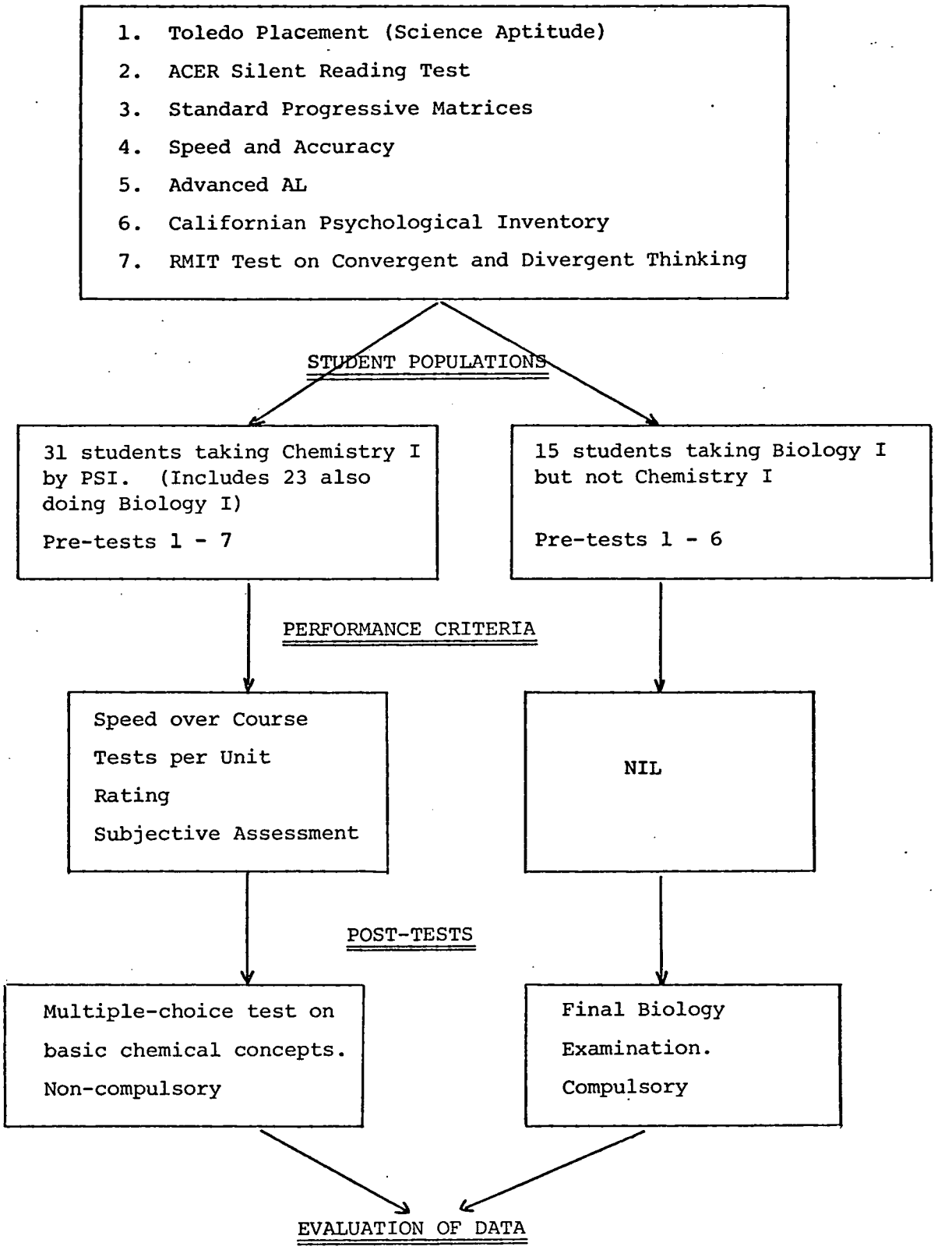


Fig. 7 Pre-test, post-test design.

introductory session was held for all students taking Chemistry I and Biology I. The teaching methods to be used in their courses were explained to them. After this they were asked to complete the pre-tests. A brief explanation of the research and its possible value to future teachers and students was emphasised. As mentioned earlier, the author was both the Chemistry instructor and the researcher.

Rather than make the pre-tests compulsory and set up an implied threat situation it was stressed that the tests were for educational research purposes, to be used for improving the course, and to assist their own and future students' learning.

As can be seen from the table of data obtained, presented later (see Table 10 , Chapter IV), most Chemistry I students completed all the pre-tests, although six students completed only some of the tests.

The Biology students not taking Chemistry were reluctant to do the tests and in order to get a substantial group of these it was decided to pay them $5.00 each for completion of all the tests.

As far as can be ascertained from talking with the students there was no animosity felt by the students who were not paid. They either took the tests because they were asked to or because they felt an obligation to the Chemistry discipline or to the researcher.

The pre-tests were administered in two complete sessions; the Chemistry I students completing theirs

in one complete four-hour session with short breaks between tests. This session was held on the first day of Semester I. The 15 Biology students who were paid took the tests in another complete session the next day. Both sessions were supervised by the researcher, equal times being given to tests and breaks and identical instructions being read to each group. In selecting pre-tests, regard was paid to student characteristics seen as necessary for success or otherwise in a PSI system.

The following tests were administered:

a) ACER Silent Reading Test (WKC)

This test is designed to measure proficiency in word knowledge, speed of reading, and reading for meaning. As the PSI Chemistry I course relies to a major degree on written study guides and textbooks for information it might be assumed that students proficient in reading skills would be better able to cope with the system. The one piece of research on this by Silberman and Parker (1974) showed that reading comprehension correlated with performance on a final examination given to a PSI Chemistry class. While there is doubt whether a final examination is a good measure of performance it provides a starting point for this present investigation.

b) ACER Speed and Accuracy (S & A)

This test is intended to measure ability to

perceive, retain, and check relatively familiar material in the form of printed numbers and names, while working to a time limit. While there is no strict time limit in doing PSI tests, speed and accuracy are often seen to be necessary for students, particularly in questions involving calculations or problem solving.

c) ACER Advanced AL (AL)

This test is designed to find a student's ability to see relationships between words, meanings of words, and concepts. In actual practice this test provides a measure of intelligence as general ability rather than separate factors. Several reports of PSI (Sherman, 1974) discuss the proposition that "bright" students can often bluff their way through verbal testing by a proctor. This may be so, but it could also be postulated that very intelligent students ought to be able to go through a PSI course very quickly and it should therefore suit them.

d) ACER Standard Progressive Matrices (PMS)

To test a person's capacity to apprehend meaningless figures presented for his observation, see the relations between them, conceive the nature of the figure completing each system of relations presented and, by so doing, develop a systematic method of reasoning.

In relation to this particular PSI course in Chemistry, the ability to solve problems, to understand the use of models in formulating theories, and to sketch molecules is stressed. This PMS test should give an indication of such abilities in students.

e) Toledo Placement Test (TP)

Normally used in the USA for science placement into colleges. A series of multiple-choice questions to test aptitude in science and comprehension of fundamental concepts. Sub-divided into sections on mathematics, physical and chemical concepts, nomenclature, and problem solving.

Since this test correlates well in USA studies with performance in college courses it is of interest to see if the same happens with PSI courses. Another point of interest is in comparison between groups of students taking different types of courses, as in Biology I and Chemistry I.

f) Californian Psychological Inventory (CPI)

This test provides a psychological inventory of each student. The scales are addressed primarily to personality characteristics important for social living and social interaction.

Success in PSI may be seen to relate to the ability of students to communicate with proctors and instructors, but it could also depend on the student's ability to gain

information and motivation from contact with other students in the learning centre and elsewhere. This PSI course was designed to operate on the mutual reinforcement and encouragement of all the people involved.

On the other hand, it could be that dominant, aggressive students might attempt to bulldoze their way through the course and the tests by force of personality and bluff. Measures have been built into the PSI system to minimize that possibility but it might still be there.

This whole question of personality interaction with performance in different types of courses is seen as an important aspect of this study. While this research was being designed a piece of related research, conducted on a national scale by another researcher, (Fearn-Wannan, 1975), proposed amongst other things to test first year chemistry students at the college for convergent and divergent thinking characteristics. Since it was possible that such characteristics might provide additional clarification of the type of students best suited to PSI, it was decided to carry out the Fearn-Wannan tests at the same time as the other pre-tests, and to use his measures as additional pre-test variables.

After taking these pre-tests students took the Chemistry I PSI course and/or the Biology I course. The performance and post-test variables to be related to these pre-test characteristics were the results on the final Biology I examination, and four variables associated with the PSI Chemistry I course.

a) Speed through the course:

Mean speeds for completion of the course were set on the basis of 1974 results and students classified according to their progress and completion graph on an eight-point scale as shown (see Figure 8).

b) Number of tests required per unit.

c) Final multiple-choice examination.

A set of 20 multiple-choice questions based on previous work was given to the students as they completed the course.

d) Classification of students by the instructor and proctors on a subjective basis.

To describe how these techniques were used to answer the questions posed for the five main areas previously identified is the purpose of the next chapter.

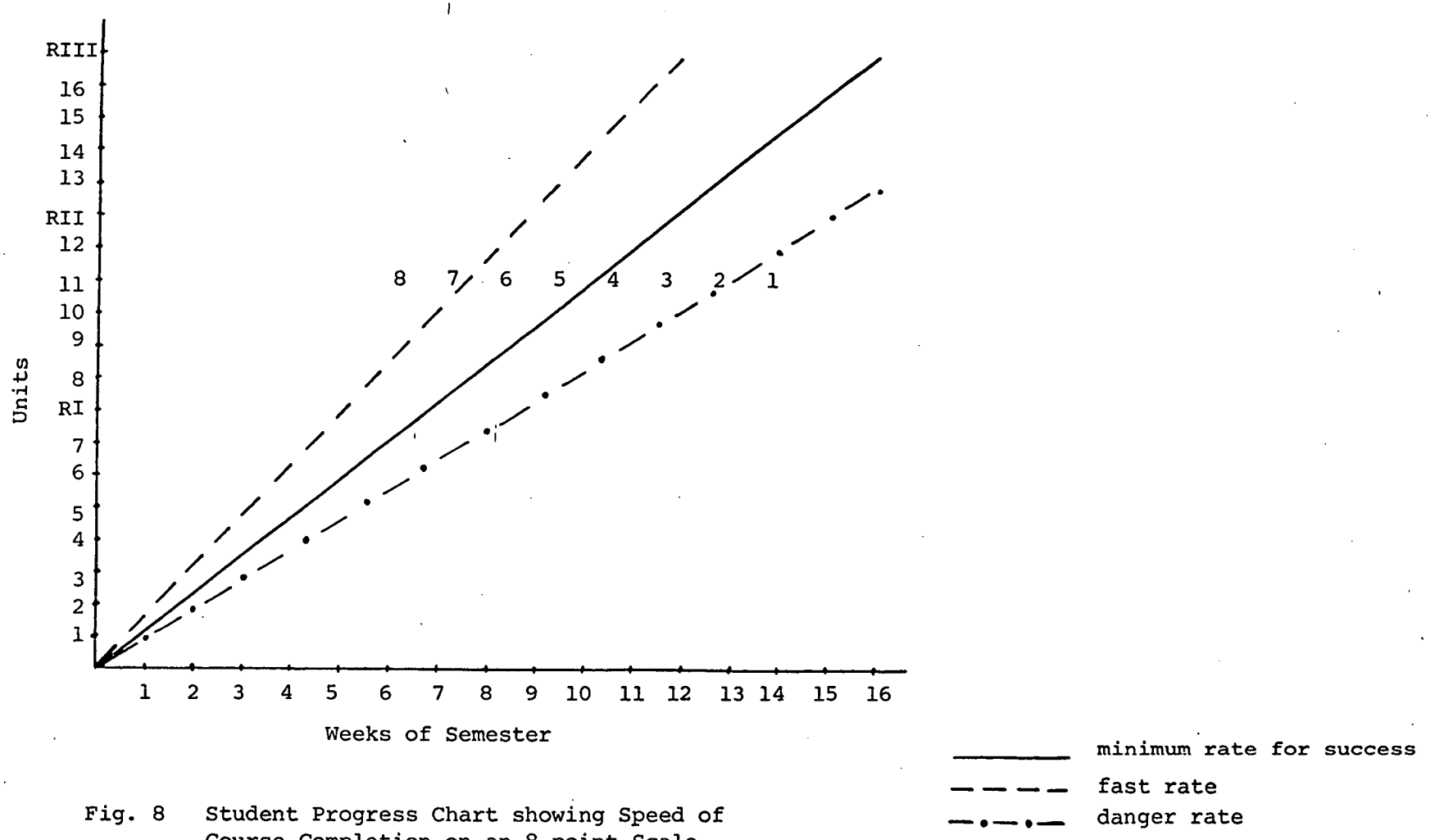


Fig. 8 Student Progress Chart showing Speed of Course Completion on an 8-point Scale

CHAPTER IV

THE EVALUATION : RESULTS AND DISCUSSION

This evaluation deals with five major areas concerned with the Chemistry I PSI course:

Course Design and Development,

Management,

Student Performance,

Student Attitudes,

Personality and Performance.

As discussed in the previous chapter, a wide range of experimental techniques were used to collect data for the evaluation. These empirical data are described, analysed, and interpreted here. The approach taken was to consider issues arising in the five areas by seeking answers to the questions posed in the previous chapter.

4.1 *Course Design and Development*

a) What problems were involved in the design of the course?

A major problem faced in the initial design stage was that there was no direct feedback possible from students until the course was trialled in 1974. The instructor, therefore, made decisions about depth of treatment of content, specification of objectives, tests, and so on without the benefit of feedback from student use. The initial source of data about the problems encountered was the subjective views of the

instructor. These were recorded at the time on videotape in an interview between an educational technologist and the instructor (Northcott VHS, 1974). The specific problems and their solutions were:

- It was extremely difficult to obtain a consensus of opinion by staff as to what should be in the course. The instructor had to act as final arbitrator or the course would have been too unwieldy.
- The writing of specific behavioral objectives was difficult at first but adherence to prescriptions set down by Mager (1962) facilitated improvement in this task.
- Study guide and multiple-test writing was enormously time consuming. The instructor obtained the assistance of other staff to assist in writing these materials and testing them. Of further supportive assistance was the use of another teacher, well versed in grammar, to edit the written materials.
- Difficulty was experienced in pitching the level of study guide objectives to enable student mastery. A solution to this was to write only the first few course units and to write further units on the basis of feedback from students completing the earlier units.

b) How enjoyable, easy to learn from, useful to the course were the following components of the units:

Objectives,

Suggested procedure,

Resources provided,

Self-test questions?

To monitor reaction to the units, the 1974 students were requested to complete feedback slips after successfully passing a unit test. These feedback slips were then analysed to assist in preparation of later units and in reconstruction of the course for 1975. A typical analysis is given in Appendix 6 by considering feedback slips obtained from one particular unit. As can be seen from these results all students thought that the unit was interesting, well organised and presented. However, 38.4 per cent found the suggested activities below average or of little help. There was a fairly even spread of opinion about the difficulty of tests taken. Against this, however, no two students who took the same test agreed on their rating on this point. Seven students commented on things they liked about the unit but perhaps, more unfortunately, nine students found something to dislike. Such dislikes helped the instructor to give some focus on how to rewrite the unit. This method of data collection worked extremely well for the first few units but poor student response later in the course rendered the systematic nature of the improvement exercise largely a matter of the subjective judgment of the instructor, reinforced by verbal student response and an analysis of student progress data.

c) Unit tests.

Detailed records of each student's progress in the course were kept and these were used to check on the units and the unit tests. The number of tests taken to pass each unit was used as a measure of test difficulty. The raw data showing individual student's records over the semester for 1974, 1975, are given in Appendix 7. The number of tests taken per unit in both years is shown in Table 2. It is interesting to note that in both years the average number of tests taken per unit was very similar, i.e. 1.62 and 1.67 respectively. This was despite a substantial rewrite of both the units and tests after the 1974 trial period. This result could be interpreted in a number of ways. Perhaps the average number of tests taken per unit is independent of the content, difficulty or type of test. Perhaps one group of students, i.e. 1975, were "better" than those of 1974.

Direct comparison between the two sets of data is, however, very difficult because the units in some cases had been rewritten for 1975 based on formative evaluation carried out in 1974. The data can, however, be used to study individual tests. For example, from the 1974 records (Table 2) it can be seen that 14 students took 31 tests to complete Unit 2, giving an average number of tests per student equal to 2.2. Considering that the overall average tests taken per unit was 1.63, it might be assumed that these tests were more difficult

TABLE 2

Number of tests taken per unit by the Chemistry I classes of 1974 and 1975

UNIT NO.	1974 N = 14			1975 N = 29		
	Number of tests taken	Difference from Mean	Difference as % S.D.	Number of tests taken	Difference from Mean	Difference as % S.D.
1	20	- 2.8	41	43	- 5.5	58
2	31	8.2	121	49	1.5	16
3	20	- 2.8	41	37	- 11.5	120
4	27	4.2	62	51	2.5	33
5	26	3.2	47	49	0.5	7
6	18	- 4.8	71	82.9	34.4	456
7	21	- 1.8	26	51.6	3.1	41
RI	15	- 7.8	115	35.4	- 13.1	174
8	14	- 8.8	129	31.1	- 17.4	230
9	22	- 0.8	12	45.7	- 2.8	37
10	33	10.2	150	58	9.5	126
11	28	5.2	76	55.6	9.5	126
12	23.3	0.5	7	52	3.5	46
RII	14	- 8.8	129	30.3	- 18.2	241
13	25.5	2.7	40	61.8	13.3	176
14	20.4	- 2.4	35	50.4	1.9	25
15	30.8	8.0	118	39.5	- 9.0	119
16	28	5.2	76	54	5.5	73
RIII	15.4	- 7.4	109	43.5	- 5.0	66
		Mean 22.8			Mean 48.5	
		$S = \frac{643.62}{14}$			$S = \frac{2467.33}{29}$	
		S = 45.97			S = 91.29	
		S = 6.8			S = 9.6	
Standard Deviation (S.D.)						
Average number of tests per student per unit	1.63				1.67	

for the students than the other tests. This can be verified because all but one student reported, on their feedback slip replies, Unit 2 tests as being difficult. Of course, another explanation might be that the students had not settled in at the beginning of their course and would find early tests difficult. This is not, however, borne out by the figures (see Table 2). There was no obvious trend in tests taken per unit as the semester continued.

A further assumption from the data shown in Table 2 for 1974 could be that Unit 8 (for a list of units see Appendix 3) and the three review units were the easiest because the number of tests taken per unit were, in all cases, less than 1.3, considerably less than the mean value of 1.63.

The most "successful" rewrite in terms of giving a result closer to the mean was Review III. Other factors, however, affect this type of interpretation. The instructor marked the review units and, if anything, the 1974 experience caused him to mark "harder" in 1975 than in 1974, and this might have been a cause for change. This is only a subjective opinion so it must also be treated with caution. A final point to be made here is that it was not the intention to make all units equal in terms of work required or standard of tests. It was not intended either that any test should be made too difficult or too easy. Given the results in Table 2, the major anomaly would appear to be Unit 6.

In 1974 this was too easy (tests per unit equal 1.3) so it was rewritten for 1975, then giving a test per unit value of 2.9; nearly double the mean value. This unit proved a definite barrier to students in 1975 and their progress graphs (see later Figure 12) show dislocations at this point where several students took some time to pass this unit. One student who dropped out remarked at the time that "Unit 6 was the finish for me".

Item analysis of unit tests was used to determine if particular questions were presenting difficulties for students and if the four tests for each unit were equivalent.

For example, the analysis of the three review units is shown in Table 3. Different numbers of students attempted each test and it would require more detailed analysis to determine whether the students who took different tests were of similar standard. Allowing for this and other problems it is, however, possible to identify questions in a given test that students found difficult. For instance, questions 4 and 8 on Test 1, Review Unit 3, obviously presented more difficulty to the students than other questions.

In the case of these review units where the tests consisted of 10 multiple-choice questions, an approximate measure of test equivalence for each unit can be obtained from the ratio: $\frac{\text{total wrong answers}}{\text{number of students attempting.}}$

TABLE 3

Item Analysis of Review Units

	Review Unit I				Review Unit II				Review Unit III			
	Test 1	Test 2	Test 3	Test 4	Test 1	Test 2	Test 3	Test 4	Test 1	Test 2	Test 3	Test 4
No. of students attempting tests	5	8	5	3	8	7	10	2	10	8	7	4
Questions	Wrong Answers				Wrong Answers				Wrong Answers			
1	-	4	-	-	1	3	3	1	-	1	1	-
2	-	2	-	-	1	3	-	2	3	1	3	-
3	2	3	1	1	-	-	1	1	-	2	-	-
4	1	3	-	-	4	2	1	-	7	5	-	-
5	1	1	-	2	5	1	1	1	2	2	1	-
6	1	-	1	-	2	2	-	-	3	3	3	2
7	5	1	1	2	-	2	7	-	2	2	1	-
8	2	-	3	1	4	1	-	-	8	1	4	1
9	-	2	-	-	-	1	1	-	2	1	1	1
10	4	1	1	1	4	4	-	-	2	1	3	2
Ratio: $\frac{\text{total wrong}}{\text{No. of tests taken}}$	3.2	2.1	1.4	2.3	2.6	2.7	1.4	2.5	2.9	2.4	2.4	1.5

In this way "difficult" and "easy" tests and questions were identified and steps taken to check whether this was indeed the case, and appropriate rewriting carried out.

What sort of changes were made in rewriting? Typical of students' reactions to study guides were that some objectives were unclear; they often asked for more directions for self-study; they were sometimes concerned that the mathematics required for some problem solving exercises were too difficult; and they thought that much of the additional reading suggested was irrelevant to the objectives given. Such student reaction guided the rewrite of the study guides. A measure of the success with the rewritten study guides used for 1975 was the almost total lack of negative student feedback. This acceptance of the study guides by students was confirmed by data from the attitudinal quentionnaire (see Appendix 4). All students agreed or strongly agreed that the written study guides were generally satisfactory and adequate. In a similar vein they all disagreed with the proposition that the units of work were too small and fragmentary.

On unit tests the students found difficulty with essay questions, with variation of types and degree of difficulty of test questions in what should have been identical tests for the same unit, and some questions they felt that were not testing the objectives. Again in the rewrite these student comments and item analyses

were used to construct equivalent and appropriate tests for each unit. Again, the success of this was confirmed by student response on the attitudinal questionnaire (see Appendix 4). All but two students agreed or strongly agreed that the tests for each unit were fair. Similarly, all but four students agreed or strongly agreed that the tests for each unit were an adequate assessment of their mastery of the material.

Summary

In this first stage of the formative evaluation of the PSI course, the subjective views of the instructor, feedback slips, student records, and test and item analysis were used to improve and rewrite the first version of the Chemistry I course for 1975.

4.2 *Management*

Together with course development, the other major thrust of the formative evaluation was in management. Initial operating procedures for the PSI course were based on reports by Keller (1968), Green (1971), and Sherman (1974), and modified in the light of feedback from the pilot operation. The course as it was operated was described in Chapter I. Here the management of the resources utilized is discussed.

a) Learning Centre Conditions

What was the rationale behind the development and use of a learning centre?

The answers to questions concerning the learning centre are descriptive and based on the observations and experience

of the instructor, students, and proctors.

Reports on PSI in operation suggest the use of a normally timetabled room for test purposes, with study being carried out anywhere that is convenient and practicable for individual students (Sherman, 1974). The pilot course in 1974 was operated in this way in a partitioned-off area in the resource material centre of the college.

Of the problems which arose, a major one was noise. A gradation from a potentially noisy informal area through a quieter study area to a silent test area was needed. Of course, not all students disliked noise, in fact some welcomed it even in the test areas. But the majority (see questionnaire discussion later) wished for the elimination of noise from central areas of the learning centre. Self-observation and student comment enabled the design of a more functional learning centre for 1975. The major opinion was that, in order to develop an optimum learning and testing environment for the students, a centre was needed that could be identified with the PSI courses.

The learning centre decided upon was subsequently constructed in a room 20 metres x 10 metres (see Figure 3, Chapter I). The rationale behind the design was basically:

a) Study area carrels could be arranged in cruciform or swastika arrangements rather than in rows. This could reduce noise levels which were a problem in the centre.

b) The test area must be kept as quiet as possible and provision made for adequate supervision of tests.

c) The audio-visual (wet) carrels need to be isolated (physically or with headphones) from the other areas. They also need to be closer to the AV materials store.

d) The informal area, for student congregation, needs to conform to students' idea of informal. Perhaps the students could select the furniture and arrange the layout.

e) There must be sufficient space for the proctors to carry out their function adequately.

f) Sufficient provision must be made to give the instructor room for private discussions with students.

g) Adequate provision must be made for storage and security of materials.

h) The centre construction must conform to safety standards.

i) Some provision needs to be made for visitors to the centre.

Other reports of PSI suggest that test sessions should be at least two hours' duration to allow for adequate opportunity for the feedback cycle to operate. (Sherman, 1974) The total time suggested per week varies with different authors. From discussions with students, student records, and observations it appeared that each student utilized the testing facilities between four to six hours per week. The PSI centre was open for testing and tutoring for 12 hours per week. Allowing for timetable clashes, this allowed all students at least four hours per week of test time.

One three-hour session was scheduled concurrently with another PSI subject to test the problems this would bring. Overcrowding, noise, and confusion were some of the drawbacks observed during these sessions. On the other hand, social contact factors, such as bringing students from different subjects and differing disciplines together in a group environment, did tend to balance out the problems. It was concluded that to program more than two classes of approximately 15 students in each for testing together was asking for trouble.

Based on the experience gained over two years of PSI operation, a further refined version of the learning centre was designed (see Figure 9) and incorporated into a new Applied Science building subsequently used late in 1976 for PSI courses.

b) Proctors

i) What do they actually do?

According to Keller and Sherman (1974): "The proctor is not only an essential feature but probably the most valuable contribution to PSI" [p.25] and, "Reward them (ie. proctors) appropriately, they are keys to the success of the system" [p.84].

Keller obviously places great emphasis on the importance of the proctor. However, the now quite voluminous literature on PSI provides only very general guidelines on how proctors should be selected and trained. Most articles tend merely to describe the experiences of proctors, either by the proctors themselves or by instructors. Moreover, the attention paid to examining the role of the proctor in the PSI literature

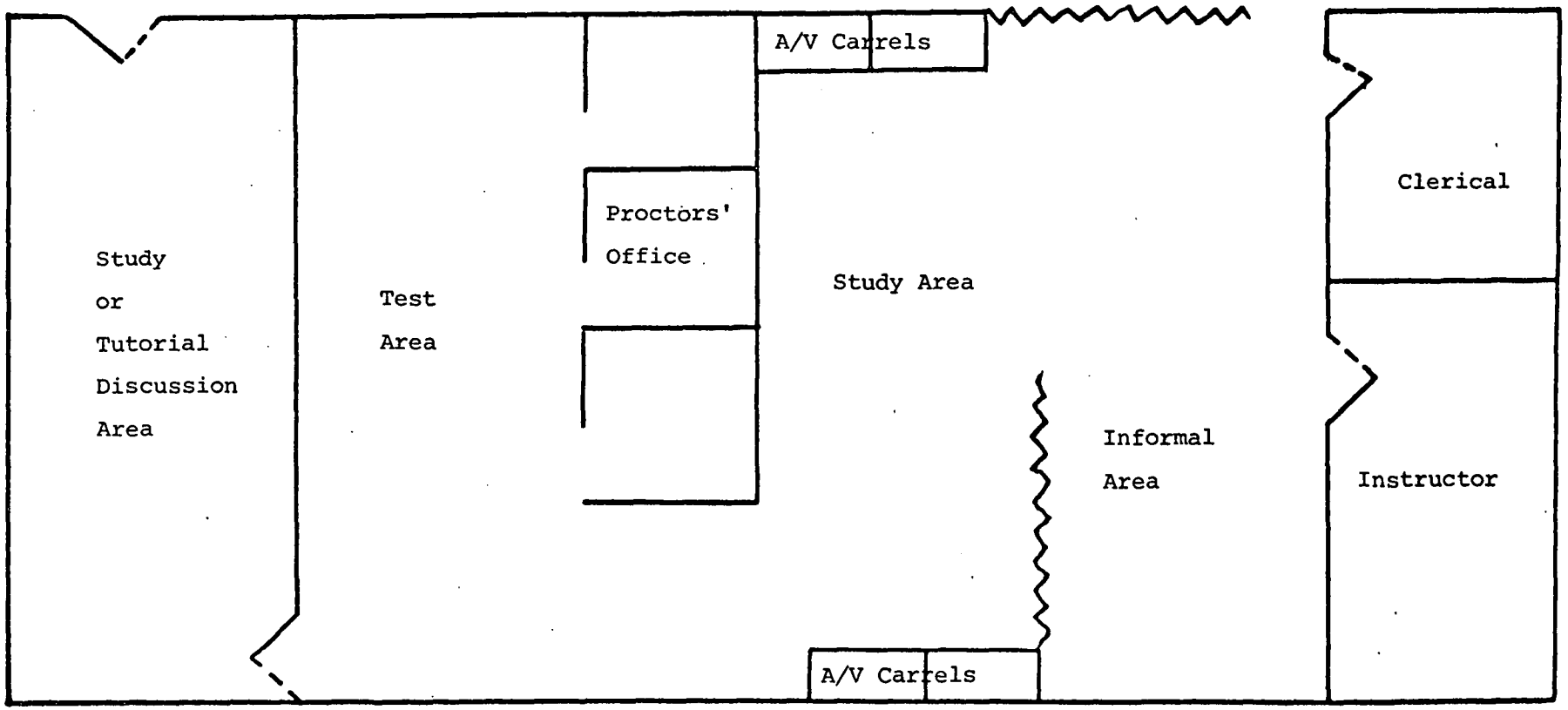


Fig. 9 PSI Learning Centre 1976.

tends to be relatively quite small.

According to Keller (1968) a proctor is an undergraduate who has been chosen for his or her:

- mastery of the course content and orientation
- maturity of judgment
- understanding of the problems of the beginning student
- willingness to assist.

Keller and Sherman (1974) have added that proctors should be chosen carefully according to the following. In descending order of importance, they should be: dependable, articulate, willing to admit what they do not know, knowledgeable.

Because the use of undergraduates as teaching assistants was a relatively novel idea to Australian tertiary education, one of the major factors in introducing PSI was the establishment and management of the proctor function. The instructor selected, briefed, and worked with the proctors in both years of the Chemistry I course. During the course operation the instructor was in close touch with his proctors both in formal briefing sessions and informally. The proctors, all students in the second or third years of undergraduate courses, handled the routine operation of test distribution, test marking against given answers, and simple problem solving in the system, relieving the instructor for more direct and important teaching and designing functions.

ii) What is the students' reaction to being proctored by fellow students?

With the 1975 proctors' consent the Educational Practices unit asked students to rate their four proctors in relation

to attributes considered by the instructor to be desirable in a proctor. A copy of this questionnaire and the results are given in Appendix 5. The students who responded, 62.1 per cent, were those who had successfully completed the PSI Chemistry course before responding to the questionnaire. As can be seen from the questionnaire results, the students' rating of proctors was overwhelmingly favourable. For all four proctors and in all nine categories the students considered the proctors to be satisfactory or superior. Later (see section 4.4) we shall see that in their responses on an attitudinal questionnaire 82.6 per cent of students regarded the assistance from proctors as being either important or very important to PSI. It is also significant that only one student objected to having other students mark his tests. Returning to the proctor questionnaire, perhaps a further gauge of student opinion was the open-ended comments written to question 10. Such comments as the following: "Easy to get along with", "Had good grasp of the subject", "Very patient", "Very helpful", and "Very willing to help and advise" were all indicative of positive attitudes of the students towards their proctors.

From all this it can be concluded that students were clear on what constitutes a "good" proctor and were in favour of the student-proctor system.

iii) What effect has proctoring on the proctors?

Several proctors have written essays about their experiences. An essay from the first proctor who worked in PSI Chemistry I in 1974 and as a clerical assistant in

1975 is enclosed as Appendix 8. As can be seen from this essay, the proctor has a very clear and enthusiastic perception of his role in the PSI program. Undoubtedly his being a foundation proctor would have influenced his behaviour, and his views are not necessarily representative of other proctors. Both this proctor and others saw themselves as providing an integral and valuable service within the PSI system. They also were convinced that they were revising and reinforcing their own earlier chemistry studies in the process of helping the students they were proctoring.

iv) What is a good proctor?

Other than that already reported in 4.2(b) above, the other sources of data about proctors were twofold. The Head of the college's Educational Practices unit interviewed three of the proctors who worked on the 1974 course. This interview was videotaped and stored in the college's AV Centre (Northcott, VHS, 1974). The other was the subjective view of the instructor who worked closely with the proctors. The instructor was also interviewed by the Head of the Educational Practices unit and this was also recorded on videotape. From an analysis of these interviews and from other data discussed earlier in the section, the following conclusion about proctors may be reached.

The views of Keller and Sherman about the essential nature of providing proctors in the PSI system have been reinforced. It is perhaps arguable who the proctor should be. Students in 1975 who had just completed the 1974 course appeared to be in a better position to proctor than more

advanced students. Such proctors being only one step removed conceptually from the students they were proctoring, were probably in a better situation to identify student problems and to send difficult students to the instructor for tutoring. Another important benefit of using student proctors is that the proctors have their own chemistry knowledge constantly reinforced and also because they develop communication skills enhanced by constant contact with other students and staff. According to students, the profile of a "good" proctor would read like this: He was a student with a good grasp of the course, was patient and helpful, was easy to get along with, and had the ability to explain problems.

That being said, there was a need for proctor training identified by both the instructor and adviser. This was subsequently fulfilled in late 1975 when a self-paced proctor training course was devised (Northcott, 1976). There is also scope for more detailed research on the proctor function, particularly as to determining the people best suited to proctoring. Are bright students better proctors than average students? Are graduate students better than undergraduate? These and other questions need answering.

c) Materials

What does the production of suitable course materials involve?

In this PSI course where dependence was placed on resources, adequate reproduction facilities were important. Even for 30 students the course required about 400 pages of

material per student. This factor alone produces a built-in reaction to change as it is expensive to re-edit and reproduce material. In the college this has been accepted and change, modification, re-editing, and reproduction is possible because the institution is resource-based. In other institutions, however, change may produce heavy cost effects.

In the Chemistry I course a substantial amount of video-tapes, films, and audio tutorial material have been developed as alternatives to the written mode. This has involved a disproportionate amount of time spent in production of materials to actual use by students. However, an appreciable amount of audio-visual material has been of benefit to the students and as it is modified by experience it is envisaged that greater dependence will be placed on audio-visual aids.

A possible step in the direction of fixed material might have to be made in the near future. For instance, after two years of development it is perhaps necessary to fix the materials at that level for, say, three years before a rewrite is carried out. This could be justified educationally as producing a sound, balanced course if the design and development stages were rigourously monitored and evaluated before fixing materials for further use. A further justification would be one of cost benefit.

Again, it must be pointed out that PSI in this context has proved to be a complex management problem as much as anything else, and all factors have to be considered in the light of the teaching-learning process before decisions are made.

d) Security

Does any form of cheating occur?

From the beginning of the project efforts were made to provide for the security of test materials associated with the PSI courses. Test papers were handed out and, in all cases, supervised in a special test area. Because of problems created by students attempting to cheat in the test areas, this supervision must be very close. Two students caught cheating had their papers destroyed and were supervised more closely in ensuing weeks. Spot tests were carried out by the instructor at frequent intervals both on test security and on marking tests. No further evidence of test cheating was observed by the instructor or reported by proctors.

At least four equivalent tests were constructed for each unit and it could be argued that it wouldn't matter if students saw all the tests in advance. For if they then learnt all the answers for all the tests they would know all they were required to do. Alternatively, there was nothing to prevent a student doing one test immediately he received a study guide to see what the test was about. Some students practised a process which was called passing by "test attrition". The students concerned soon realized that this system took them longer than following the study guide and then doing a test. The design method of making this short-term memory style of passing units redundant is to have regular review units which test the bringing together of material from the previous group of units.

e) Costs

i) What does the course cost:

in terms of man-hours;

part-time assistance;

proctors' fees;

by comparison with a conventional course?

The costs of implementing and expanding a PSI system are important:

For 48 students you require for the PSI equivalent of a three-hour lecture, one tutorial, three hours practical per week (see Table 4).

For 100 students taught conventionally for this one subject a department would require, at the very least, two lecturing staff to give a conventional staff/student ratio of 12.5 : 1 (which is high). This would cost, based on the figures in Table 4, $28,000 or $280 per head, at the very least and certainly more with part-time assistance in the laboratories. Thus in a developing situation the cost per head for PSI courses can become much less than the conventional system.

ii) How can PSI courses be run more efficiently?

For an even more cost effective system at the college the instructor has been experimenting with running PSI courses in different chemistry subjects concurrently. Thus the learning centre was open for testing for 12 hours per week for students from four different chemistry subjects. The laboratories were likewise open to students from these four subjects for 12 hours per week on a student self-

TABLE 4

PSI versus Convential Course costs

1 Instructor	-	Lecturer say,	$ 14,000
1 Clerical Officer	-	12 hours/week at $3.38 per hour for 32 weeks	1,300
Proctors	-	5 @ $3.00 per hour, 3 hours/week for 32 weeks	1,440
Demonstrators	-	4 @ $7.50 per hour, 3 hours/week for 32 weeks	2,880
			$ 19,620

i.e. Cost per student - $408.75

For 100 students in the PSI mode -

Instructor	-	$ 14,000
Clerical Officer	-	1,300
Proctors x 10		2,880
Demonstrators x 8	-	5,760
		$ 23,940

i.e. Cost per student reduces to $239.40 *

(* These figures are dated at 1975 salary levels.)

selection basis. Thus the one full-time staff member ran four subjects in a total time of 24 hours per week with assistance from demonstrators and proctors.

In this context it is perhaps relevant to quote Mackenzie *et al* (1971):

> Higher education, as a result of soaring costs, levelling enrolments, ever decreasing finances, must inevitably look to educational technology - the software of education - to provide new types of quality educational systems. The very survival of higher education depends upon acceptance of this fact. [p.174]

iii) Is it possible to transfer the use of such a course?

As far as transfer of the course was concerned, the college is a split campus with branches in two cities. The teaching of Chemistry I is undertaken at both sites using the same syllabus but different staff. It was the original intention to study the success or otherwise of transference of material produced at one centre and used at another. While there was extensive co-operation and liaison between staff at both sites it is felt that the second operation of PSI has not been the 'success' it was in the original site. For various reasons, mainly financial and staffing, it was not possible to operate the PSI system at the second site in anything like the detail applied in the first. For instance, changes were made to the order of materials used and the times at which they were used. Also the staff who designed the PSI system and produced most of the materials were based in the original city. The commitment to PSI was therefore at this city and this perhaps as much as anything contributed to the problems encountered at the other site.

It appears, therefore, that attempts to transfer the PSI system and materials to another situation must be accompanied by more detailed planning before implementation.

Summary

Management of the PSI system was a complex operation requiring constant attention to detail and the provision of a learning environment tailored to meet student needs. As well as incorporating the elements of the original Keller plan a PSI learning centre was designed and constructed. It was found also that students had positive attitudes towards the use of student proctors. A student profile of a "good" proctor was one with a good grasp of the course, was patient and helpful, was easy to get along with, and had the ability to explain problems. It was found possible, within the normal constraints of the college system, to run a resource-efficient, cost-effective, innovative PSI program in Chemistry I.

4.3 *Student Performance*

a) How did the students perform in this PSI Chemistry I course, and how does learning by this method compare with learning by other teaching methods?

From records kept of student progress over the four-year period, 1973-76, it is possible first to describe how students in the PSI years of 1974, 1975, performed and how these compare with student performance in a conventionally taught course in 1973 with the same instructor, and in the PSI course of 1976 with a different instructor.

During the pilot program in 1974, 15 students commenced the course. At the end of the first semester, normally the completion date, 10 had completed the course, one had dropped out; the remaining four students completed the course during the second semester. Of the 10 students eligible to go for a higher grade, four did so, all gaining credits.

The figures for 1975 show a similar pattern. Of 29 students who commenced the course, 21 completed at the end of the semester, four dropped out and the remaining four completed the course during the second semester. Higher grades were obtained by 11 students, the distribution being two high distinctions, three distinctions and six credits.

In analysing these figures, a comparison can be made with the 1973 Chemistry IA class, taught by the same instructor, in a conventional lecture format and examined by a final examination. Grades as percentages over the four years, 1973-76, are shown in Table 5.

TABLE 5

Students' Grades, Chemistry I 1973-76 by percentage

	1973 (19)	1974 (15)	1975 (29)	1976 (30)
HD	0	-	6.9	2.6
D	10.5	-	10.3	12.8
CR	21.1	26.7	20.7	10.3
P	57.9	66.7	51.8	56.4
F	10.5	6.7	10.3	17.9

The 1976 figures relate to the PSI Chemistry I class run by a different instructor in new premises and with major modifications. Circumstances, such as the release of a Government report recommending the closure of the college, were also quite different from those governing the previous three years. Allowing for this and for obvious differences in the other three years the general pattern of results is reasonably similar. The higher withdrawal rate in 1976 was probably due to loss of morale among students, particularly those who had not progressed very much when the closure report was made public in April.

Individual student progress over 1974, 1975, has been included as Appendix 7. This gives the number of tests taken per unit, the week in which each unit was passed, and the completion date. From these figures the overall student progress in 1974 and 1975 can be plotted as tests passed per week over the 16 weeks of the semester (see Figure 10). A further measure of progress is to plot students completing the course by week (see Figure 11). Taking these two measures together it is reasonable to see that tests passed after Week 12 declined rapidly as more students completed the course.

Individual student progress can be traced from graphs plotted of units passed per week of course (see Figure 12). Avey and Northcott (1975) have examined such graphical records and have proposed a division of students into four basic categories on the basis of common patterns.

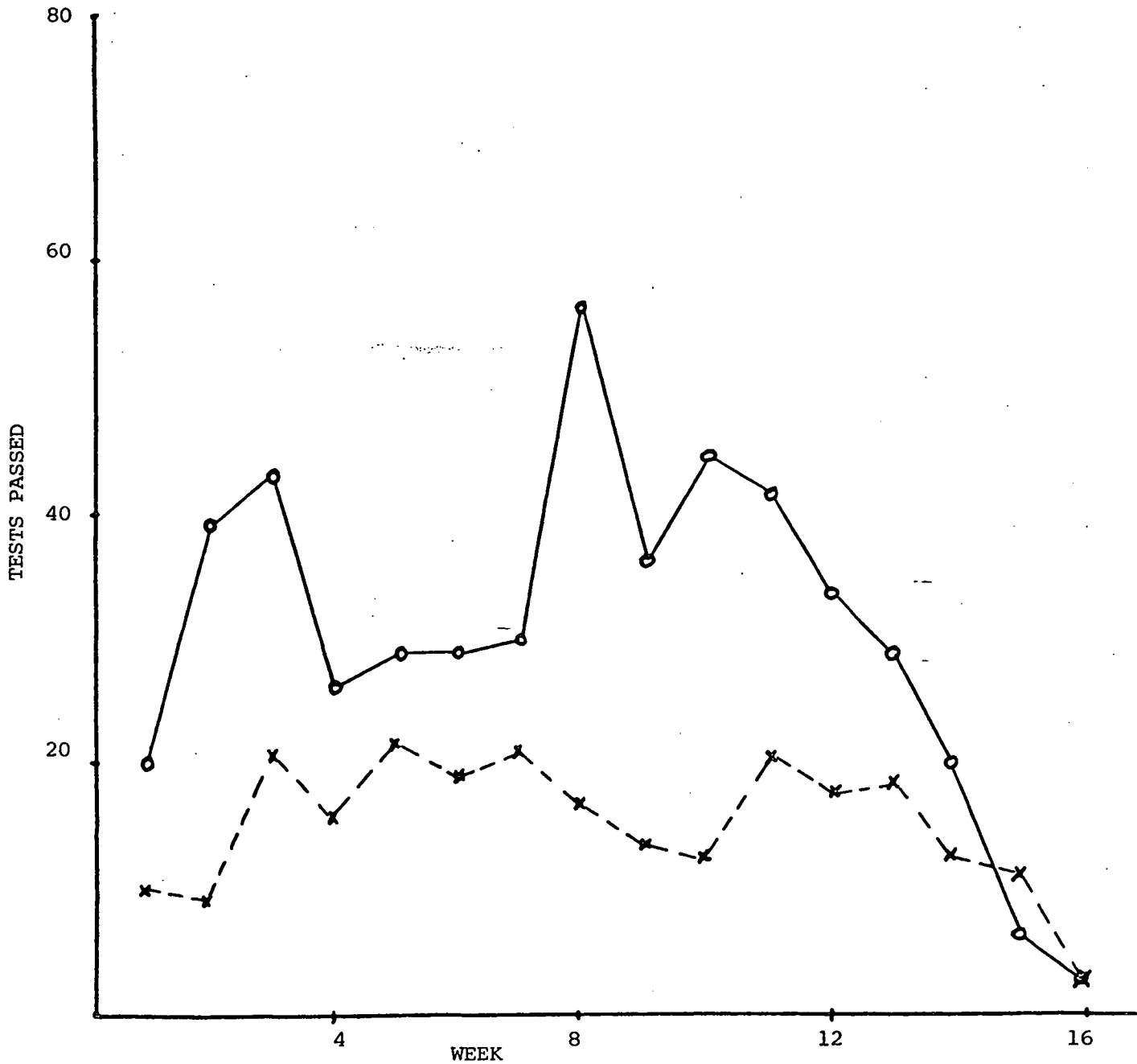


Fig. 10 Total Tests passed per Week
Chemistry I

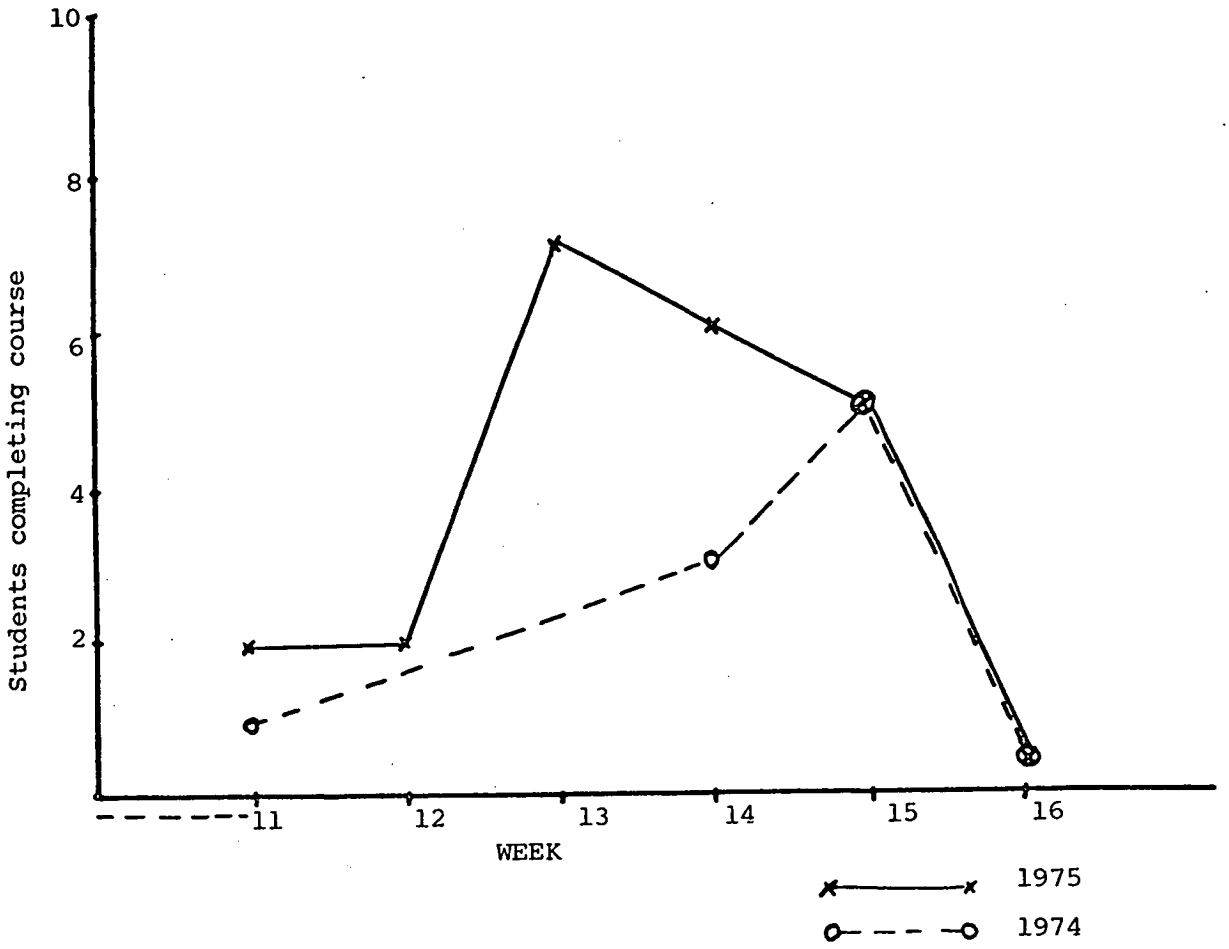
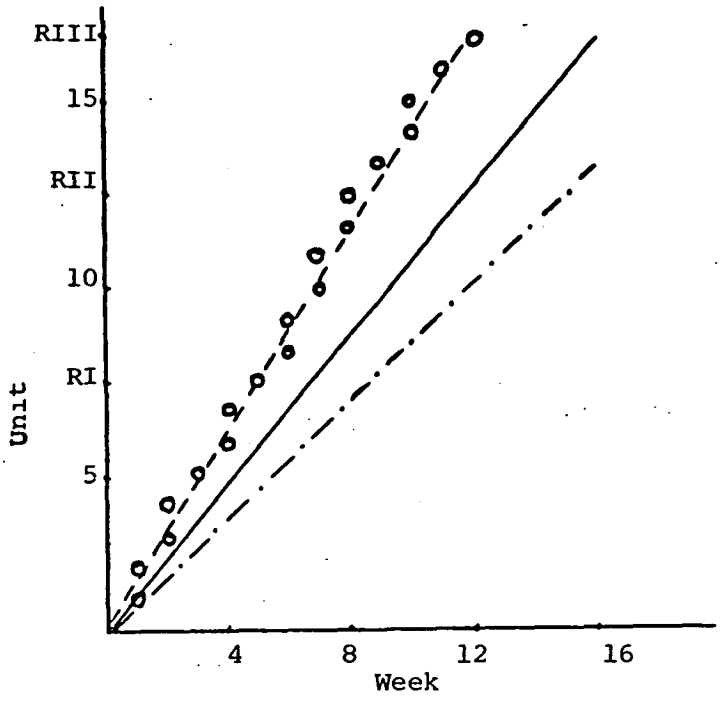
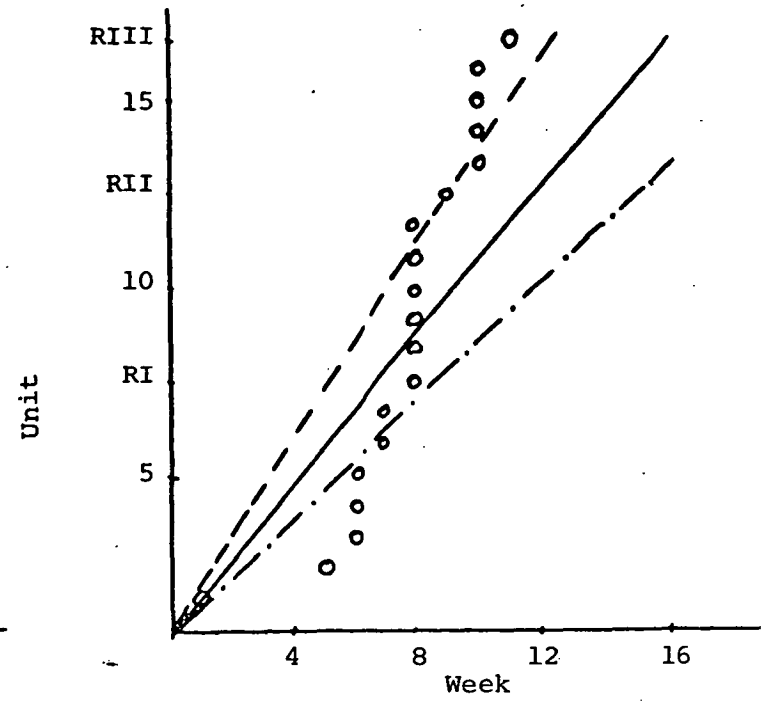


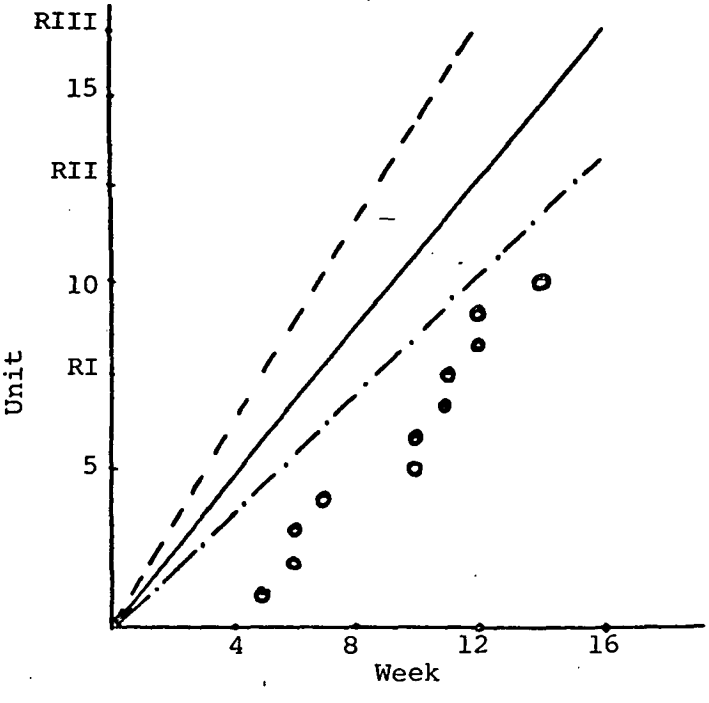
Fig. 11 Students completing Chemistry I Course by Week



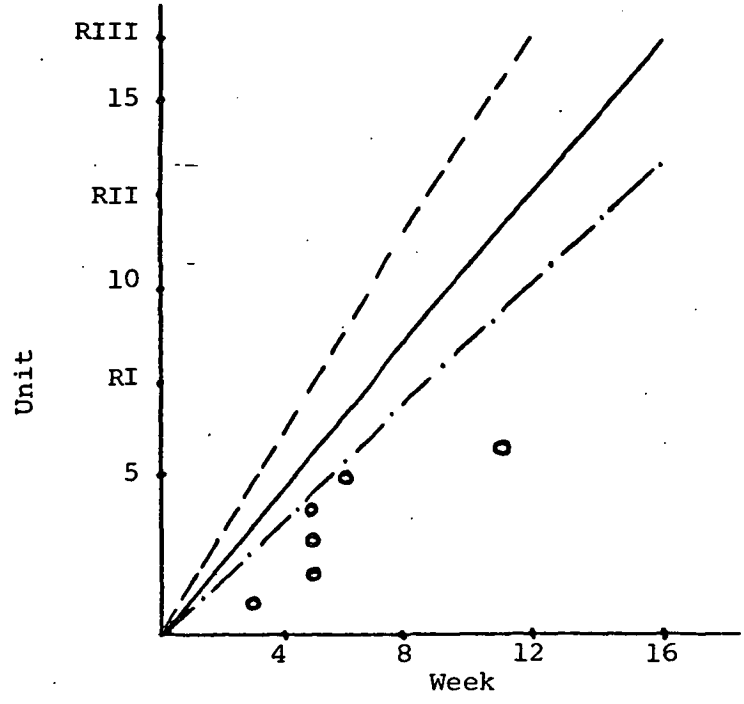
(a) Continuous



(b) Concentrated



(c) Procrastinator



(d) Potential Withdrawal

- - - - Fast

——— Medium

—·—·— Slow

Fig. 12 Characterization of Individual Student Progress

i) Student who Progress at a Continuous Rate

Many students show this characteristic pattern. The students in the main are of two types - the fast finisher who goes through the system very quickly, usually with a low number of tests per units, and the student who paces himself through the course just maintaining a rate sufficient to complete the course in the semester.

ii) The Concentrated Study Pattern

This pattern is usually associated with students who finish the course quickly without any special problems. The student often takes and passes several tests in a week, perhaps delays for a few weeks and then has another burst of test taking.

iii) The Procrastinator

This type of student often goes for weeks without taking a test and usually ends up falling behind schedule. Most eventually complete the course in the following semester.

iv) Potential Withdrawal

It becomes very quickly apparent that some students are having difficulties with the course. This type of performance is often associated with taking a high number of tests per units.

While it is clear that these four main types have sub-sets and mixed patterns, it is nevertheless possible to use such graphical analysis in the management of the PSI learning environment.

b) Is procrastination a problem? If so, how can it be overcome?

There is evidence to suggest that some, perhaps most, students prefer to work in concentrated bursts. Parlett and King (1971) go so far as to suggest that most students when left to schedule their own work will study subjects (topics) in depth for concentrated periods of time and are diverted from doing this by timetables and assignments imposed on them from a number of subject specialists. Continuous rate progress (as distinct from concentrated study) especially if it is also a rapid rate, may be more appealing to the instructor than the student.

Various authors reporting on PSI courses have described procrastination as a major problem. Green (1971), Austin and Gilbert (1973), Gallup (1970) and, in particular, Robin (1976) reported on this problem (see earlier discussion in Chapter II). One of the design aims of the PSI Chemistry I course was to manage the system to reduce procrastination and to provide sufficient rewards and encouragement to the students to keep them going in the course.

The problem in checking procrastination was to retain the positive PSI reward system and not introduce the aversive aspects of deadlines. Attempts to do this included the use of schedules:

i) Fast rate

ii) Slow rate

iii) Rates which may result in exclusion.

However, there is difference of opinion as to whether

the educational advantage of the student fixing his own schedule is so important that it should not be nullified by imposed (even suggested) schedules. The commonsense answer is probably to treat the local situation and the individual student's case on its own merits.

With the context of the PSI system used, the implementation of the basic procedures should help to curb procrastination. That is:

> Early completion of units allowed the students to take either an exam earlier than the end of semester (and repeat exam if he wished) or to do extra units for a higher grade.
>
> Units were kept small - say, three to four hours' study time. Students were made aware of suggested study times on the written guide for each section of the work.
>
> An effort was made to provide clear, unambiguous and motivating study guides and associated study materials.
>
> Ample opportunity was given for students to take readiness tests and they were encouraged to take tests to enhance learning. A self-test was provided with each study guide.
>
> Tests were marked immediately upon completion by a proctor in front of the student.
>
> Students had ready accessibility to instructor and proctor.
>
> A pin-board was located in a prominent place

showing how many units each student has passed.

A significantly different anti-procrastination device utilized in this Chemistry I PSI course was the deliberate attempt to create a favourable social environment in the specially designed PSI learning centre (see section 4.2 above).

c) Were the anti-procrastination measures successful?

Robin (1976), in his review of research on behavioral instruction, concluded that such instruction averaged a 14 per cent dropout compared to 10 per cent for lecture-discussion courses. In specifically Keller plan type courses Born and Whelan (1973) reported dropout rates of 14.4 per cent, 25 per cent and 14 per cent in three different courses. The 14 per cent reported by Robin can, therefore, be considered as a baseline.

Now let us consider the four categories of students described in (a) above. From individual progress graphs it was possible to put the students into these categories (see Table 6).

TABLE 6

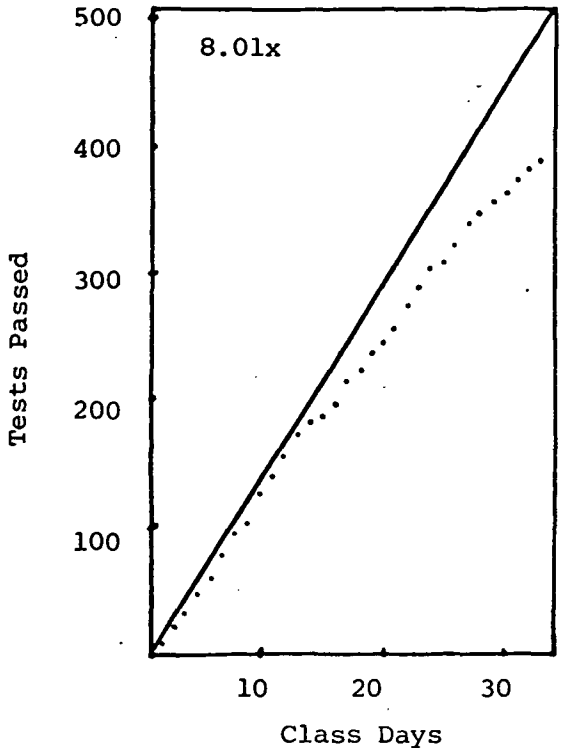
Student Categories

		1974 (%)	1975 (%)
i)	Continuous	46.7	34.5
ii)	Concentrated	33.3	41.3
iii)	Procrastination	13.3	13.7
iv)	Withdrawal	6.7	10.4

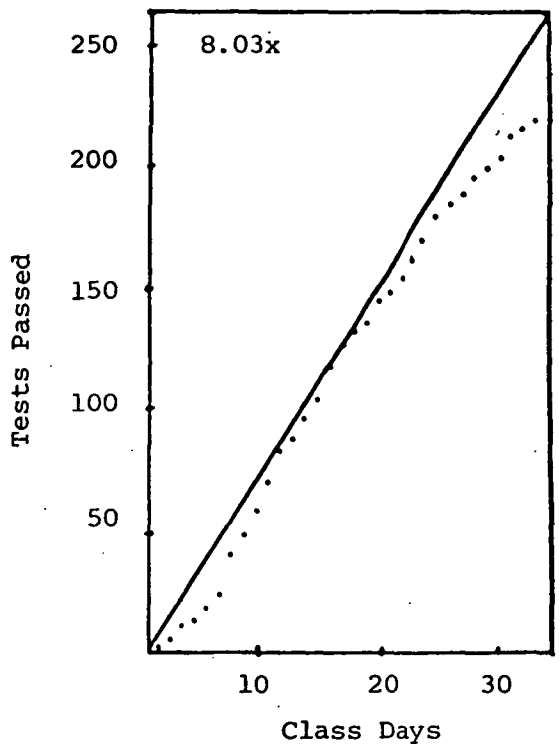
It is perhaps a measure of the success of the anti-procrastination measures that only 9 per cent (four students), over the two years, did not complete the course. This is marginally less than the 10 per cent average report for lecture oriented courses. Also 13.6 per cent (six students) could be classed as procrastinators, although all six eventually completed the course in the following semester.

Of the successful students, 38.6 per cent could be classed as continuous workers and the sample percentage as concentrated study people.

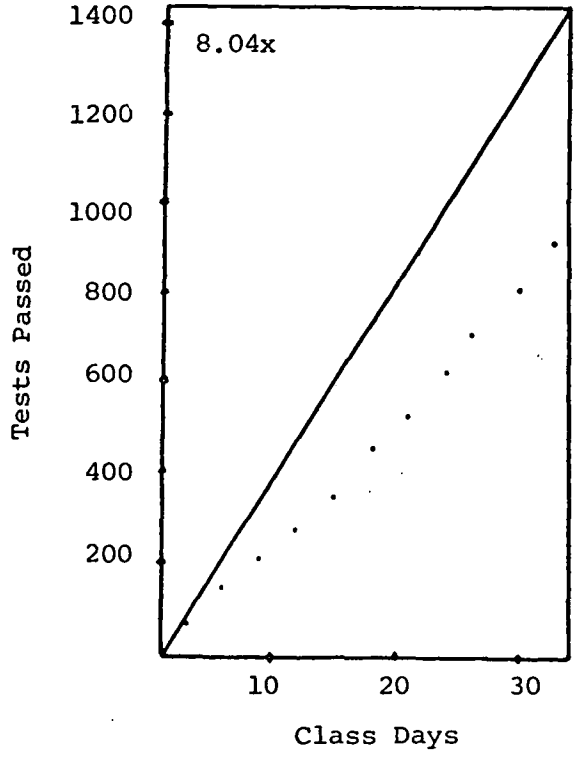
Another appropriate measure of procrastination has been employed by Green (1971), Austin and Gilbert (1973), and Hoberock (1971) who used a graphical method of analyzing total class performance. A plot of cumulative test passes per week of semester was used (see Figure 14). On this graph of the average rate of passes was also plotted, the theoretical straight line representing the optimum conditions for all the class to finish by the end of the semester. Green postulates that the gap between the theoretical straight line and the actual progress curve is a measure of procrastination. He supports this with evidence from three physics courses, two run by himself, another by a colleague. The corresponding graphs used by Green are shown in Figure 13. He has postulated that the slow rate of progress shown in Figure 13c was because the instructor had allowed the students to complete the course in the following semester, while in Green's own courses, Figures 13a and 13b, the students were given no time extensions; that is, a great deal more procrastination in the former course but not in the latter two courses.



(a) Total tests passed by class in subject 8.01x vs class days, fall 1970. (The straight line would result if all students worked at a steady rate and finished on time.) The students were freshmen.



(b) Total tests passed by class in subject 8.03x vs class days, fall 1970. The students were sophomores.



(c) Total tests passed by class in subject 8.04x vs class days, fall 1970. The students were sophomores.

Fig. 13 Class Progress Charts (after Green, 1971)

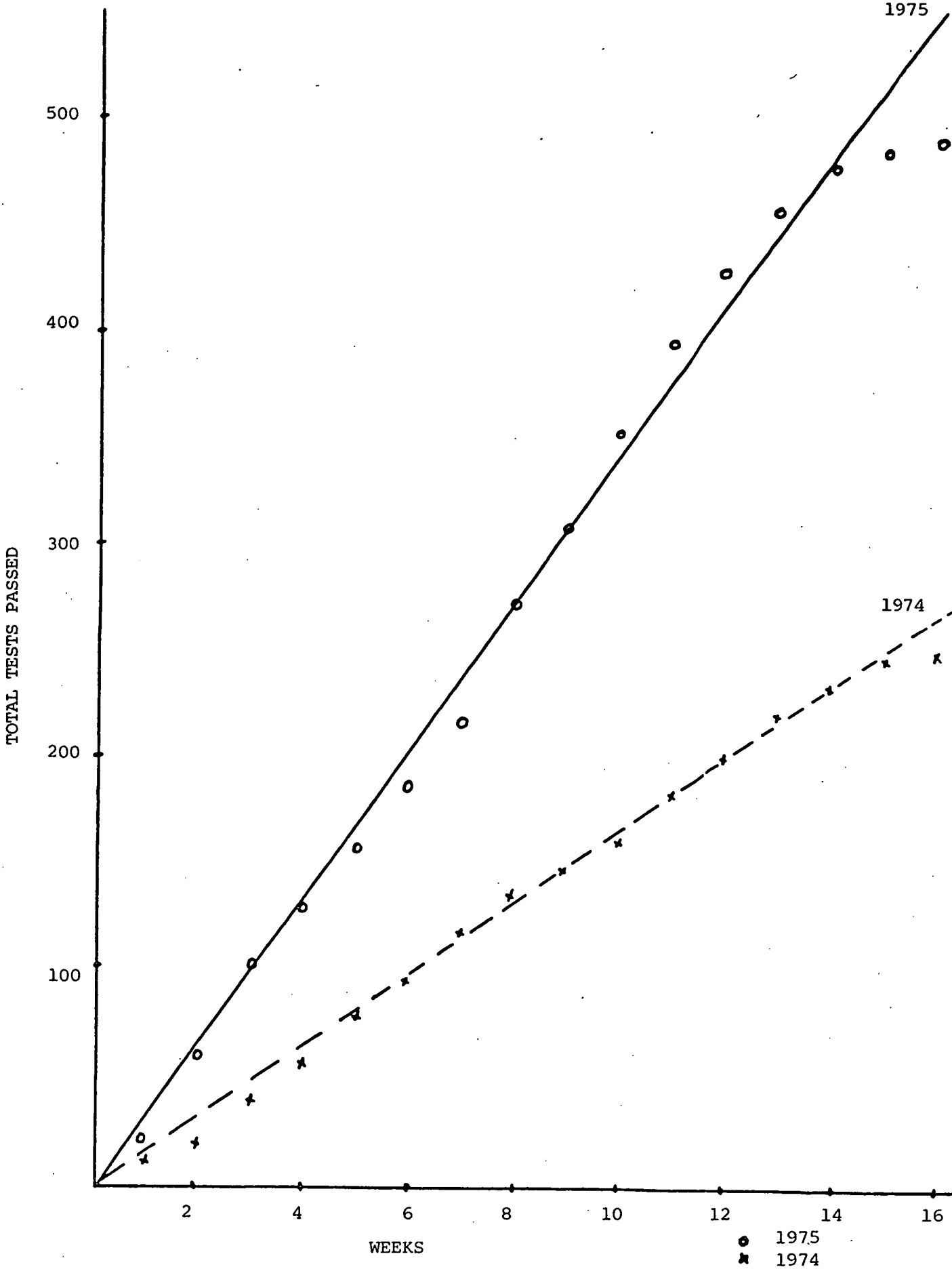


Fig. 14 Total tests passed per week as compared with ideal standard pass rate (straight lines), 1974, 1975.

In a similar fashion, the average rate of work in the PSI Chemistry I courses of 1974, 1975, were plotted (see Figure 14). While there are obvious differences between the chemistry and physics courses, there are obviously similarities between the graphs. In the Chemistry I courses, where students could complete in the following semester, there is no evidence of procrastination as in Figure 14. In fact, the chemistry curves are remarkably similar to Green's classes (Figures 13b, 13c) where the students had to finish that particular course within one semester.

Despite the fact that cross experimental comparisons such as this can be notoriously weak the anti-proscrastination techniques employed in the Chemistry I course were successful, ie. within a liberal self-pacing PSI scheme, it is possible to minimize procrastination.

Summary

Performance of students in the PSI course, as measured by grades achieved, was at least as good as in the conventional course of 1973. The problem of procrastination, highlighted by Robin (1976), was combated by several measures. On minimizing dropouts, on successful course completion, and in terms of procrastination measures proposed by various authors and in this study, this Chemistry I PSI course was successful.

4.4 *Student Attitudes*

As discussed in Chapter II, many authors have reported on favourable student attitudes towards PSI courses. The

general course questionnaire used in the Chemistry I course has a two-fold aim. First, to assist in formative evaluation of the course and, second, to confirm or deny that students taking the course have a favourable attitude towards PSI.

In 1974 the results were used to help rewrite the course for 1975 and to assist the instructor in deciding on changes to the management of the system. The questionnaire used is shown in Appendix 4. In 1974, seven students, ie. 46.7 per cent of the students responded. A summary of the results is given in Appendix 4. While the response rate was low, the students obviously liked the PSI system and considered the clear specification of objectives, self-pacing, and multiple-testing as very important facets of PSI. Perhaps the most valuable information from the questionnaire responses were the comments students added at the end. The seven students added comments - some at quite some length.

A clearer indication of student attitudes was obtained from responses to the 1975 questionnaire from 23 students, ie. a 79 per cent response. Having just completed the course the students obviously had a clear conception of the PSI system (see Table 7) in that they rated the major components of PSI as very important. The one exception was the importance of optional lectures and other activities for which over half the students expressed a negative or neutral importance. As well as giving a rating to features of the Keller plan, students were given space to comment on their choice of rating. A selection of thes comments shows that

TABLE 7

Post Course Questionnaire 1975

Student Attitudes to Features of the Keller Plan

FEATURE	RESPONSE RATING					
	Very Important 4	Important 3	Neutral 2	Un-important 1	Very un-important 0	MEAN RATING x
1. Clear specification of objectives on study guide	19	3				3.9
2. Self-pacing facility	16	7				3.7
3. Mastery level competence (i.e. achieving very high scores on tests)	11	10	2			3.4
4. Multi-testing (i.e. the opportunity to repeat a test without penalty)	13	9	1			3.5
5. Selection of own study activities to fulfil objectives	3	11	8			2.8
6. Assistant from proctor (student tutor)	7	12	2	2		3.0
7. Review Units	9	8	4	2		3.0
8. Optional lectures, films, semonstrations	1	8	7	6		2.2
9. Small-sized units of works	6	13	3	1		3.0

the students had gained an understanding of the basic elements of PSI (see Appendix 4).

To more specific statements relating to their experience in the PSI course the students' opinions are shown in Table 8. This can be summarized to mean that the students agree or strongly agree that:

i) the amount of material learnt in the PSI course is greater than in most other courses taken;

ii) contact with the instructor was greater than with other courses;

iii) the feeling of being an integral member of the group and course;

iv) the PSI system encourages enthusiasm for the subject;

v) knowing the results of a test immediately after each unit is very beneficial;

vi) study habits had changed significantly for the better as a result of doing the PSI course;

vii) no objection to having tests marked by proctors;

viii) written study guides are generally satisfactory and adequate;

ix) would like to take another course in the future that uses the PSI format;

x) the tests were an adequate assessment of mastery of the material;

xi) the units of work were not too small or fragmentary;

xii) more material is retained from the PSI plan than other courses.

TABLE 8

Post Course Questionnaire 1975

Student Response to Statements about their Experience in the Keller Plan System

STATEMENT	RESPONSE RATING					
	Strongly Agree 4	Agree 3	Neutral 2	Disagree 1	Strongly Disagree 0	MEAN RATING x
1. The amount of material I learn/learned in the KP course is/was greater than in most other courses I have taken	5	11	5	2		2.8
2. I was <u>not</u> always able to gain information or help about the material I did not understand		8	3	11	1	1.7
3. I took advantage of the opportunity to ask questions of a proctor (student tutor)	1	18	3	1		2.8
4. I <u>never</u> took advantage of the opportunity to ask questions of the lecturer (instructor)				18	5	0.8
5. My study habits have significantly changed for the better as a result of doing the course	5	9	5	3	1	2.6
6. To profit from a KP course one has to have appropriate study habits <u>before</u> doing the course	3	7	4	7	2	2.1
7. I was unhappy to see other students completing units before me	1	4	5	11	2	1.6
8. I object to having my tests marked by a proctor (student tutor)		1		11	11	0.6
9. My contact with the lecturer (instructor) is/ was greater than in other courses I am/ have taken	4	12	2	5		2.6

TABLE 8 (cont.)

STATEMENT	RESPONSE RATING					
	Strongly Agree 4	Agree 3	Neutral 2	Disagree 1	Strongly Disagree 0	MEAN RATING x
10. The written study guides are generally satisfactory and adequate	6	17				3.3
11. I would like to take another course (i.e. one in the future) that uses the KP format	13	9	1			3.5
12. The tests for each unit are fair	5	16	1	1		3.1
13. The tests for each unit are an adequate assessment of my mastery of the material	6	12		4		2.9
14. The units of work were too small and fragmentary			1	18	4	0.9
15. I felt I was an integral member of the group and course	4	14	5			3.0
16. I retain more material from the KP course than from other courses	1	14	4	3	1	2.5
17. A KP course stifles creativity and individual initiative	1	2	2	10	8	1.0
18. The KP course encourages enthusiasm for the subject	8	10	3	1	1	3.0
19. Knowing the results of a test immediately after each unit is beneficial	14	8	1			3.6

The students were finally asked about their attitudes towards the course and how they saw it in comparison to the lecture-seminar format of conventional courses (see Table 9). Of particular interest here were:

Item 8: Seventeen of the 23 students declared that they had become more interested in chemistry because of the PSI course. Considering that the majority of students were not chemistry majors but pharmacy or medical technology students, it is significant that the PSI course made them more favourably disposed towards chemistry itself. This favourable attitude should have a flow-over benefit to the study of chemistry-related subjects in future years.

Item 6: Nearly all the students thought that occasional seminars should be incorporated in the course. In follow-up interviews it was difficult to pinpoint the reasons for this. Some students said that they were missing out on something that they felt was a beneficial part of their conventional courses. Others thought that they would like a more overall view of the courses that they thought only the instructor could give. Still others wanted more group contact between students. All, when questioned, acknowledged the difficulty of holding group seminars in a PSI course when the students participating would be at different stages in the course.

Summary

In general, from the 1975 course questionnaire results

TABLE 9

Post Course Questionnaire, 1975

Student Response to Questions about the Keller Plan

1. What do you <u>like</u> about the Keller Plan course?

Self-pacing (14)
Continuous assessment (5)
More interesting (4)
Covers material more thoroughly (4)
Greater retention of knowledge (5)
Transfer of responsibility to student (2)
Adaptability to suit individual (3)
Individual assistance available when needed (2)
Even spread of work - no cramming (5)
Good, informal, interesting course (2)
Students get to know each other better (2)
Working individually a good incentive
Course takes the pressure off the student - help available when needed.

2. What do you <u>dislike</u> about the Keller Plan course?

Students can pass units without understanding them fully
Workload can be too demanding
Too much pressure built up if lagging behind
Some of the proctors unnecessarily tough when marking
Tendency to learn a little, fluke a test and forget all you know
No major changes necessary
Constant pressure of steady work pace can be gruelling, but results are better
Irrelevance of certain test questions to the objectives of the unit

TABLE 9 (cont)

Objectives of the course are not always direct enough - they are misleading

time a bit restrictive. Would like to have had more than one unit at a time to study

Too much noise in the PSI Centre

There being no lectures in generally difficult topics, tutors repeatedly answer the same questions individually

Time-consuming when seeking advice

Students in difficulty may be overlooked until too late

Dislike the grading system - prefer simple pass/fail.

3. Which type of assessment do you most prefer?

End of year exam only	-
End of semester exam only	-
Continuous assessment and end of semester exam	4
Continuous assessment only	18
Indifferent	1
Other (please specify)	-

4. How time-demanding do you think a KP course is compared with a lecture/seminar course?

Much more time-demanding	4
More time-demanding	7
About the same	9
Less time-demanding	3
Much less time-demanding	-

5. Which do you consider is more intellectually demanding, a KP or a lecture/seminar format?

Lecture/seminar more demanding	5
KP more demanding	13

TABLE 9 (cont)

5. (cont)

About the same	2
Don't know	2

6. Would you like to see occasional seminars incorporated according to the slow rate?

Yes	15
Unsure	6
No	2

7. How does the KP course compare with your expectation of the course?

Much better than anticipated	8
Better than anticipated	11
About what I expected	4
Disappointed with the course	-
Very disappointed with the course	-

8. Has your attitude towards the subject of chemistry changed as a result of doing the KP course?

Very much more interested	5
More interested	12
Unchanged	5
Less interested	1
Very much less interested	-

it can be seen that students reacted very favourably to the PSI Chemistry I course and that their interest in the subject had increased during the course. A further measure of acceptance of PSI among students has been their repeated requests to the instructor and to other staff to utilize PSI further in teaching other subjects.

4.5 *Personality and Performance*

4.5.1 The Questions

PSI is an education system that provides for individual differences between students in that it allows students to study how and when they want to and to proceed at their own pace.

a) Is this really so?
Does PSI allow equal opportunities to all students?
Does PSI suit all students?
Are students of differing abilities equally suited to PSI?

b) Are personality factors to be considered against student performance in PSI courses?

To begin to answer these questions, a pre-test, post-test, quasi-experimental design was set up to investigate the relationship between personality and performance in the PSI Chemistry I course and a more conventional Biology I course. As discussed above (see Section 3.4.10), characteristcs of students taking these courses were measured by pre-tests. The

performance and post-test factors to be related to these pre-test characteristics were the results on the final Biology I examination and on four factors associated with the PSI Chemistry I course.

i) Speed through the course.

ii) Number of tests required per unit.

iii) Final multiple-choice examination.

iv) Subjective classification of students by instructor and proctors.

It is obvious that these criteria suffer from various deficiencies. Speed is not necessarily related to quality of work. The number of tests taken can relate to other factors. For instance, some students take an initial test after little study while others prepare exhaustively. Subjective assessment is notoriously subject to personal bias.

The multiple-choice examination at the end of the Chemistry IA course should have provided an objective basis for post-testing students but several problems arose. The test of 20 questions was constructed by identifying the basic concepts taught in the course and then writing items to assess the students' understanding of these concepts. The test was then shown to other members of staff and the senior proctor, and the items were modified in the light of comments received. However, when the students took the test (voluntarily) at the completion of the course, it because obvious from student comments that several of the questions were

ambiguous. In retrospect, this test should have been trialled in 1974 or validated over a larger student population before being used as a post-test variable. A major problem, however, was that only successful students took the test, ie. those who had passed all the units, and some of these took the test very reluctantly. Both the proctors and staff supervising the test noted that students often did not take the test seriously and either did not hand in the test or did it very quickly. With hindsight, it would have been better either to have made the test compulsory or to have paid the students for taking it. While the results of this test, with ambiguous items deleted, has been used in calculating correlations with pre-test items, it was considered by the instructor an unsuitable measure of assessment of students in the Chemistry I course.

It was accordingly decided, therefore, to produce a "chemistry performance rating" from the student's records kept during the course. Several combinations of factors were considered and the results compared with the instructor's subjective assessment that had been made during the course.

Since neither the speed over the course (as defined in Section 3.4.10) nor average number of tests per unit relate isomorphically to performance for reasons discussed above, a rating which appeared most likely to be of use was a ratio of the two:

$$\text{Rating factor} = \frac{\text{Speed over the course}}{\text{Average number of tests per unit}}$$

and put on a scale of 1 - 100. To see if this was an adequate measure of student performance, these factors were checked against the subjective assessments of the instructor and proctors. This showed good correlation, and this perhaps crude instrument was used as a measure of good student performance. To protect the identity of the students they have been classified as numbers 1 - 29 based on their order in the weighting scheme rather than by name or alphabetical order.

Each of the pre-tests a - d, described above, provides one variable and the CPI test, eighteen. The CPI variables have been standardised against male and female norms and put on standard scales with respect to one another. All other variables are raw scores. The variables are shown in Appendix 9, all on a scale of 1 - 100, except where otherwise stated.

The next step was to examine the correlations between pre-test and either performance or post-test variables. The first calculations were of correlations between each pre-test variable and each performance and post-test variable, e.g. between their Toledo Placement test results and the biology examination results. The Pearson coefficient of correlation (r) was used as a measure of correlation.

Because the sample size is fairly small, 35 or less, the error in representing the sampling distribution by the normal curve is not however negligible. To calculate the significance of the correlations, a simple student's

t-test is performed. For the correlations calculated in this study, the students have been combined in four different and overlapping groups.

a) Students taking Chemistry I.

b) Students taking both Chemistry I and Biology I.

c) Students taking Biology I but not Chemistry I.

d) Students taking Biology I.

The raw data is listed in Appendix 9 and from this it can be seen that not all students in each group took all the tests. Wherever possible, the sample size (n) considered has been kept the same. Correlations calculated are shown (see Table 10). Means and standard deviations of all scores are also show (see Table 11).

Given then the relatively small sample sizes used and the statistical values calculated, what conclusions can be drawn from the single correlations shown (see Table 10)?

4.5.2 *Discussion of results*

1. Students taking Chemistry I

Consider first the correlations with the results of the Chemistry I objective test. Given a sample size of $n \leqslant 19$, a value of $r > 0.46$ or < -0.46 is required for significance within the 5 per cent confidence level. The only variable that approaches these limits is capacity for status with $r = -0.50$, a significant negative correlation. This general lack of correlation could, of course, have been expected

TABLE 10

SINGLE CORRELATIONS OF PRE-TEST CHARACTERISTICS WITH POST-TEST RESULTS

	Chemistry Rating		Biology Result			Chemistry Result	
n =	(23)	(19)	(19)	(15)	(34)	(16)	
CHEMISTRY I							
Speed over course	.91						
Tests per Unit	-.55						
Rating			.76			(17)	-0.01
Biology Result				.59		(17)	-0.21
Toledo Placement (TP)	(28) .11	.16	.20		(38) .55	(19)	.01
WKC	(26) .12	(18) .05	.06	-.22	(36) .07	(17)	0.21
SPM	(26) .43	(18) .10	.21	.54	(34) .18	(17)	-0.14
S & A	(27) -.02	(18) -.06	.22	.32	(37) .52	(17)	-0.07
AL	(27) -.10	(18) -.14	.40	.41	(37) .41	(17)	0.41
Californian Personality Inventory							
Dominance Do	.19	-.41	-.42	.05	-.19		0.17
Capacity for Status Cs	-.24	-.50	-.46	-.07	-.28		0.01

		Chemistry Rating		Biology Result			Chemistry Result
	n =	(23)	(19)	(19)	(15)	(34)	(16)
Sociability	Sy	.19	-.14	-.26	-.10	-.22	0.01
Social Presence	Sp	-.08	-.18	-.26	.20	-.24	-0.21
Self-Acceptance	Sa	.09	-.14	-.20	-.46	-.26	0.06
Sense of Well-being	Wb	.33	.20	.29	.23	.17	-0.01
Responsibility	Re	.24	-.06	-.02	-.15	.00	0.22
Socialization	So	.41	.35	.52	-.16	.19	-0.20
Self-Control	Sc	.02	.16	.15	-.13	.19	-0.12
Tolerance	To	.07	.14	.33	-.07	.05	-0.09
Good Impression	Gi	-.03	-.24	-.43	.28	.02	-0.24
Communality	Cm	.28	.21	.45	.23	.12	-0.05
Achievement via Conformance	Ac	.42	.24	.08	.33	.25	-0.40
Achievement via Independence	Ai	-.03	.05	.33	.19	.16	+0.01
Intellectual Efficiency	Ie	.36	.06	.25	.18	.23	+0.12
Psychological-Mindedness	Py	.06	.07	.06	.05	.10	-0.39
Flexibility	Fx	.30	-.09	.13	.67	.14	0.26
Femininity	Fe	-.04	.33	.17	.13	.05	-0.0

TABLE 11

MEANS AND STANDARD DEVIATIONS

	Objective Test		Chemistry Rating 23		19		Biology Result 19		15		34	
n = 19												
TP	55.53	11.67	(28) 54.82	12.61	(19) 59.74	8.85	59.74	8.85	38.73	15.00	(36) 49.14	15.78
(17) WKC	91.41	5.21	(26) 91.27	5.46	(18) 91.12	5.11			88.00	4.38	(36) 89.72	4.69
(17) SPM	84.94	6.68	(26) 84.81	6.96	(18) 84.83	6.29			88.85	4.72	(34) 86.47	5.92
(17) S & A	18.24	3.03	(26) 17.58	3.61	(18) 18.94	1.76			17.68	3.16	(37) 17.54	4.13
(17) AL	18.00	4.49	(26) 17.11	5.51	(18) 17.72	4.39			15.13	4.07	(34) 15.89	5.13
n = 16												
Do	39.25	10.26	38.30	11.65	39.84	9.58	Ditto		40.67	13.20	40.21	11.14
Cs	40.38	9.02	42.26	9.97	41.47	9.63			41.38	8.70	41.26	8.98
Sy	45.00	9.40	44.83	9.68	46.05	9.00			47.87	8.71	46.85	8.78
Sp	45.75	9.53	47.35	9.09	46.84	10.10			54.40	7.58	50.18	9.72
Sa	49.63	15.12	50.61	14.59	51.74	14.87			52.87	8.39	52.24	12.28
Wb	39.19	13.93	34.96	14.85	36.26	14.09			40.80	11.28	38.26	12.74
Re	41.13	6.85	40.35	8.54	41.05	7.21			38.07	9.20	39.74	8.16
So	43.50	8.59	40.96	8.89	41.53	8.34			42.07	9.71	41.76	8.83
Sc	47.81	7.42	45.06	9.31	45.42	10.01			38.13	8.68	42.21	10.00
To	43.19	7.00	43.30	7.77	42.89	7.77			45.00	9.55	43.82	8.53
Gi	44.50	6.72	43.61	6.29	43.74	6.68			39.13	7.93	41.71	7.51
Cm	35.06	15.42	32.44	17.17	32.63	15.21			47.29	6.73	38.85	14.23

	Objective Test		Chemistry Rating 23		Chemistry Rating 19		Biology Result 19		Biology Result 15		34	
Ac	42.19	5.33	40.61	6.21	41.05	6.03			38.33	7.08	50.62	8.46
Ai	48.88	8.86	47.74	9.26	49.05	8.57			52.60	8.18	39.85	6.56
Ie	41.31	10.38	37.83	12.13	39.37	10.56			37.40	13.07	38.50	11.59
Py	49.19	7.11	49.74	6.21	49.32	6.63			47.00	9.89	48.29	8.18
Fx	51.63	9.91	52.09	11.94	52.37	11.59			63.13	12.73	57.12	13.10
Fe	46.31	8.46	46.48	10.08	44.37	9.53			49.13	8.83	46.47	9.40
(19) Rating Result	53.42	10.94	(20) 37.60	7.42			(17) 24.71	5.62				
MC	6.82	2.24	(27) 7.22	2.49			7.00	5.62				
VC	8.71	2.47	(27) 8.78	2.83			8.81	2.93				
VF	51.00	11.48	(27) 47.35	12.18			49.35	12.06				
(17) IF	35.18	9.93	(27) 31.82	10.61			(21) 33.19	11.28				
UF	13.41	5.59	(27) 12.48	7.21			14.05	7.41				
CF	15.18	6.18	(27) 13.63	6.12			14.38	6.25				
UFX	9.47	3.16	(27) 9.48	5.60			14.05	7.41				
CFY	10.59	3.89	(27) 9.70	4.54			10.05	4.65				

because of the problems encountered in administering and marking the objective test (see above).

Secondly, the performance variable, ie. chemistry rating, was correlated against all the pre-test variables. For the first five variables only the SPM correlates meaningfully with performance. For the 26 students concerned (n = 26) the value of r = 0.43 is within the 5 per cent confidence level.

For the CPI variables, n = 23 and two of these, socialization (r = 0.41) and achievement via conformance (r = 0.42) are significant within the 5 per cent confidence level. The CPI scales are related mainly to personality characteristics important for social living and social interation. The scales can be divided into four classes (a list of abbreviations for CPI scales is given as Figure 15).

i) Measures of poise, ascendancy and self-assurance. (Do - Wb)

ii) Measures of socialization, maturity and responsibility. (Re - Cm)

iii) Measures of achievement potential and intellectual efficiency. (Ac - Ie)

vi) Measures of intellectual and interest modes. (Py - Fe)

In interpreting these CPI scales there is a large base of research available and commonly accepted behaviors are attributable to each scale (Gough, 1964).

High scorers on socialization So can be expected

Do	Dominance
Cs	Capacity for status
Sy	Sociability
Sp	Social presence
Sa	Self-acceptance
Wb	Sense of well-being
Re	Responsibility
So	Socialization
Sc	Self-control
To	Tolerance
Gi	Good impression
Cm	Communality
Ac	Achievement via conformance
Ai	Achievement via independence
Ie	Intellectural efficiency
Py	Psychological-mindedness
Fx	Flexibility
Fe	Femininity

Fig. 15 CPI Variables - Meanings of Abbreviations

to be "serious, honest, industrious, modest, obliging, sincere and steady; as being conscientious and responsible, and as being self-denying and conforming" [p.10]. Similarly, high scorers in achievement via conformance (Ac) can be expected to be "capable, co-operative, efficient, organised, responsible, stable and sincere; as being persistent and industrious; and as valuing intellectual activity and intellectual achievement" [p.11].

There is a marked similarity between the So and Ac scales. It is possible, therefore, that performance in PSI could be favoured by high scores in both these categories. It is reasonable to postulate that PSI, as a highly organised learning situation, requires conformance to the system by students who are also conscientious hard workers.

2. Students taking Biology I

Here the sample sizes vary from n = 34 (CPI variables) to n = 38 (Toledo Placement). Significant positive correlations with the biology result are not found at all with the CPI variables where a minimum value of r = .34 is required for significance within a 5 per cent confidence level. On the other hand, results on Toledo Placement (TP), Speed and Accuracy (S & A), and ACER Advanced AL (AL) tests correlate significantly with the biology result.

It is difficult to see why speed and accuracy correlate highly with the examination result because, according to the lecturer concerned, the examination

did not necessarily require those skills nor, for that matter, the biology course in general. On the other hand, high correlations with AL and TP might be expected. The AL is a type of intelligence test and the TP a scientific aptitude test for college entrance in the United States of America. Both tests have shown high correlation with performance at conventional final examinations in first-year college examinations.

3. Students taking Biology I but not Chemistry I

In this case n = 15. For this an $r > .51$ is required for a significant positive correlation to be assumed. As can be seen the Toledo Placement and PMS meet this requirement from the first five pre-test variables and only flexibility (Fx) from the CPI variables when compared with the biology results. This group is a subset of (2) above. As can be seen from the table in Appendix 9, these 15 students obtained a lower average mark on the biology test than the 19 also taking PSI Chemistry I. The correlation of biology result with PMS, an intelligence test measuring ability to develop a systematic method of reasoning and, to a lesser extent, the correlation with AL, another IQ factor relates student performance to IQ. The TP correlation as found in (2) is also evident here, probably for the same reason. The biology result correlation with flexibility (Fx) fits into this same general pattern. Fx is an indication of the degree of flexibility and adaptability of a person's thinking

and social behaviour and is a measure of intellectual and interest modes.

4. Students taking both Chemistry I and Biology I

This is perhaps the most interesting group to study, because there is the possibility of directly comparing the same group of students on two post-test variables. Results, however, are disappointing but not wholly unexpected. For n = 19 (n = 18 in four cases), there are no strong correlations between pre-test variables and the chemistry rating. For correlations with the biology result, two CPI variables, socialization ($r = .52$) and communality ($r = .45$) meet or nearly meet the minimum requirement of $r > 0.46$ for significance at the 5 per cent level.

Socialization was one of the factors that correlated meaningfully with chemistry rating (see (1) above). It was noticeable also that the correlations of all variables with both chemistry rating and biology result were very similar, suggesting that the 19 students did equally as well individually in both course types. This was confirmed by the high correlation ($r = 0.76$) between the chemistry rating and biology result. This general similarity in performance is further underlined by a significant negative correlation between Capacity for Status (Cm) and both chemistry rating and biology result. High Cm scorers can be seen as ambitious, active, forceful, insightful, resourceful, and versatile. In PSI it might be supposed that such students might try

to dominate the system and perhaps attempt to influence unduly the proctors into passing borderline tests. However, the high negative correlation between Cm and chemistry rating shows that this was not the case in the Chemistry I PSI course.

In considering the four cases discussed above, there are many other points to be taken into consideration. For instance, the Toledo test is used in America as a science placement test for conventional college courses. It could be expected, therefore, that students taking conventionally assessed subjects, like biology, could be classified on a Toledo test as to their chances of successfully completing a Biology I course.

For another, the use of the objective test to measure success in the Chemistry I course was a fiasco. Future use of such tests must be subject to student validation prior to use. Even then this form of assessment may not be relevant to this course. Perhaps the final test should be moulded on the style of the PSI tests used in the course before it could tell anything about student achievements in that course.

If we consider students taking Chemistry I, it is possible to make some general conclusions from those correlations that are significant. Considering 'success' as being completion of the PSI Chemistry I course in minimum time with a minimum number of tests per unit, students, therefore, who have marks above the

mean on pre-test variables PMS, So, and Ac have a good chance of performing successfully in the PSI course.

There are, however, no such predictors of marks or success on the objective Chemistry I test. If we consider students taking both Biology I and Chemistry I, better than mean results in pre-tests TP, So, and Cm would predict at least a pass in Biology I. On the other hand, for all biology students those with above the mean results in TP, S & A, and AL would have a good chance of passing the Biology I examination. Rather than attempt to use only single predictors of performance it is possible to combine predictors or, at the ultimate, to build up a personality profile of 'successful' students in either the chemistry or biology courses.

4.5.3 *Combining interactions*

The Californian Psychological Inventory (CPI) gives, in a single test, 18 variables about the beginning students. For this reason and because of the possibility of building up personality profiles of students, it was decided to concentrate on these items.

For the group of students taking Chemistry I (for which CPI scores are available) it can be seen that the correlation was highest for the So and Ac scales against the performance rating in the PSI course. A more powerful predictive tool could perhaps be achieved by combining the Ac and So scores and then correlating

this combined score with the performance rating.

To build up multiple correlations between variables and performance criteria, multiple regression analysis could be used. However, the computing facilities for this were not available, and it was considered that in the circumstances sufficient multiple correlations could be calculated manually to see if this combining of scales was potentially useful.

To combine the two predictors, Ac and So then, the technique of a pooling square was used (Lewes, 19 ?). The correlation between the two predictors was calculated to be 0.37 (cf. typically 0.50) and the suffices 1, 2, and 3 in the pooling square refer to the criterion and two predictors respectively. Viz:

	1	2	3
1	1.0	.42	.41
2	.42	1.0	.37
3	.41	.37	1.0

This square is then summed for predictors and criterion giving the form

A	C
C	B

i.e.

1.0	.83
.83	2.74

where the combining correlation

$$r_{2,3} = \frac{c}{\sqrt{AB}} = \frac{.83}{\sqrt{1.0 \times 2.74}}$$

which is more significant (within the 5 per cent confidence limits) than either the So or Ac correlation.

If now a plot is constructed of student distribution over the two scores against their ranking in the performance rating, the following is obtained (see Figure 16).

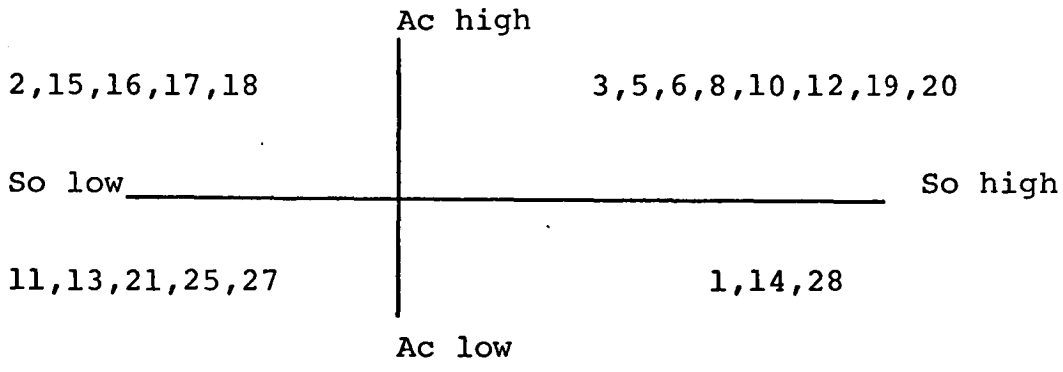


Figure 16

Ac/So interaction with ranking in performance rating, Chemistry I, 1975

Students in the Ac high/So high region have scores on both scales above the means for each scale. Failures, drop-outs, and incompletes are Nos. 23 - 28. Clearly, students with above average Ac scores have been successful and the same can be said of high So scorers except No. 28. If, however, only high scorers in both Ac and So are considered, it will be seen that all have passed the Chemistry I course. This, therefore, could be used as a predictive tool for giving students who will meet the minimum performance level in the PSI course.

Calculations of interactions between all scales have not been carried out. What was done, however, was to combine several pairs of scales, either because they correlate fairly well on an individual basis with the chemistry rating or because they intercorrelate well between themselves.

The combined correlations with the Chemistry I performance rating are given below.

$r_{Ac,Wb} = 0.47$ $\quad$ $r_{Ac,Ie} = 0.35$

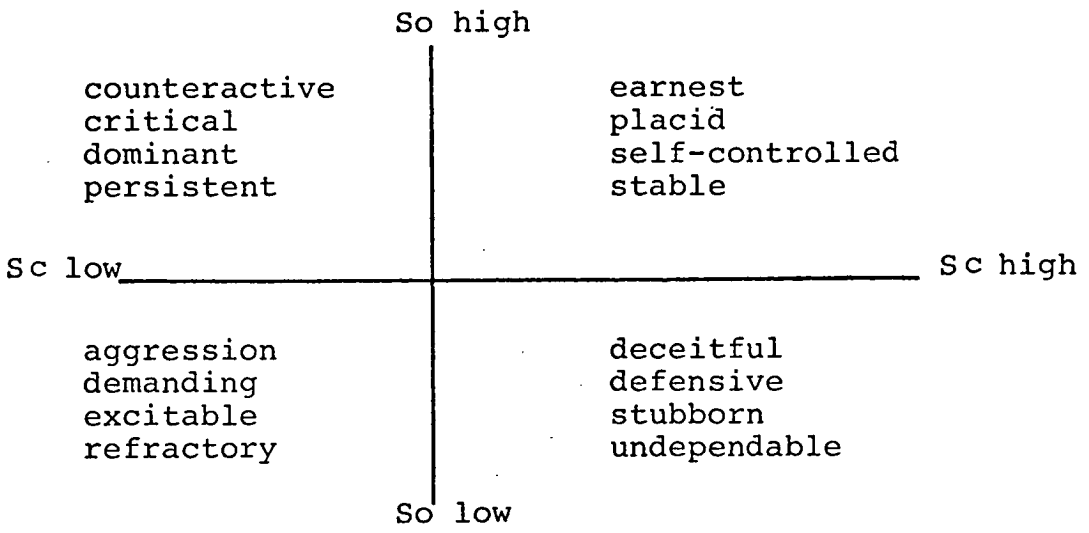
$r_{Do,Sy} = 0.22$ $\quad$ $r_{Ac,Ie} = 0.48$

$r_{So,Sc} = 0.27$ $\quad$ $r_{Ac,So} = 0.39$

$r_{Ac,Ai} = 0.25$

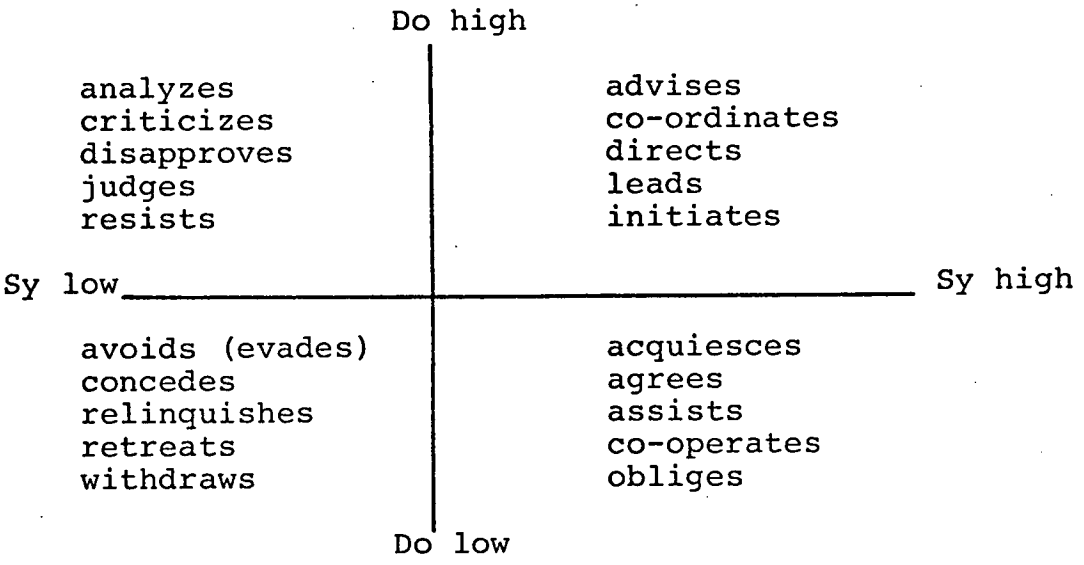
Plots of student distribution against scores for other combinations of CPI variables were carried out but the results were inconclusive.

In looking at other correlations one could expect, for instance, that the So/Sc combination would have the following characteristics.



Except for the No. 28 anomaly, it can be seen (Figure 16) that the majority of 'successful' students fall into the So high/Sc high category. Again, however, this result has to be looked at in the context of the combined correlation of r = 0.27 which is lower for So as a single correlation.

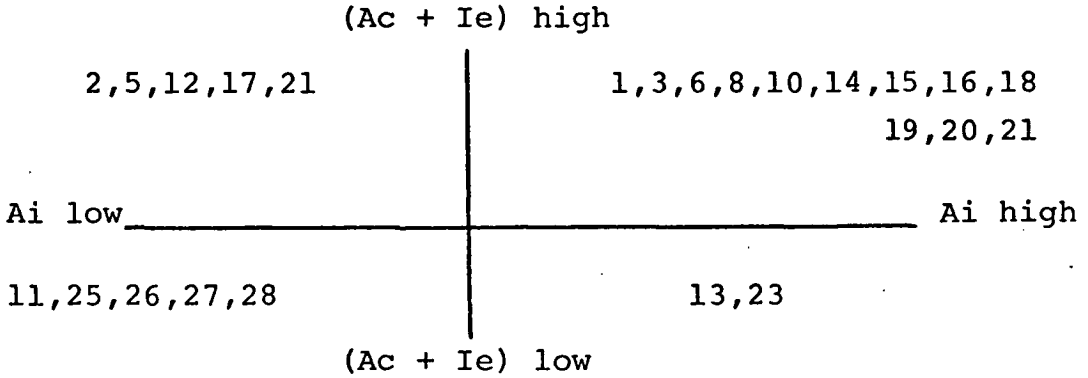
Consider, finally, in this section the interaction between dominance (Do) and sociability (Sy) which could give some idea of how students might react in the small group situation likely to be favoured by this PSI course. The combination could be expected to show

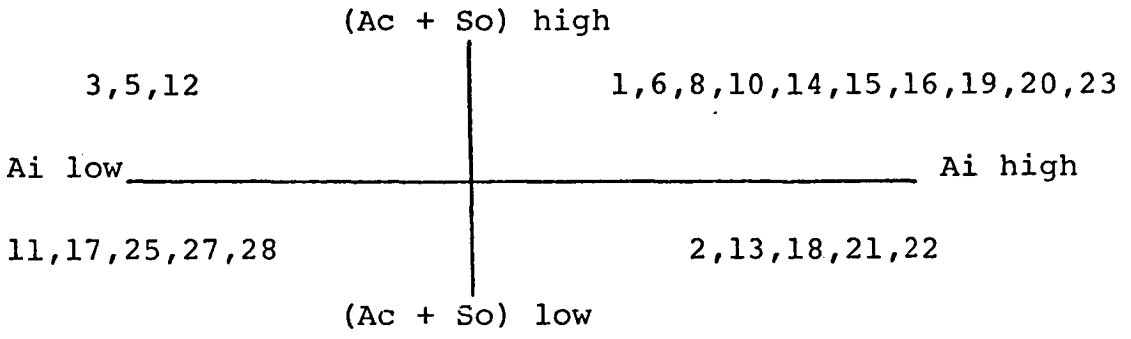


From Figure 16 it can be seen that the results of this combination were inconclusive, with the 'poor' students distributed in the high/high and low/low sections. However, the majority of successful students fall in the two Sy high regions and, given the characteristics of these, suggests that active participation is necessary for operating effectively in the PSI group.

4.5.4 *Multiple interactions*

Because the simple combination of CPI variables was inconclusive, a more advanced method of combination suggested by Gough (1964) was attempted. This was to combine two scores, interact this with a third and relate the distributions to performance in the PSI Chemistry I course. Considering the three measures of achievement, potential, and intellectual efficient, a possible combination is the two higher scores (Ac + Ie) interacting with the low score (Ai). The following distribution is given (see Figure 17).





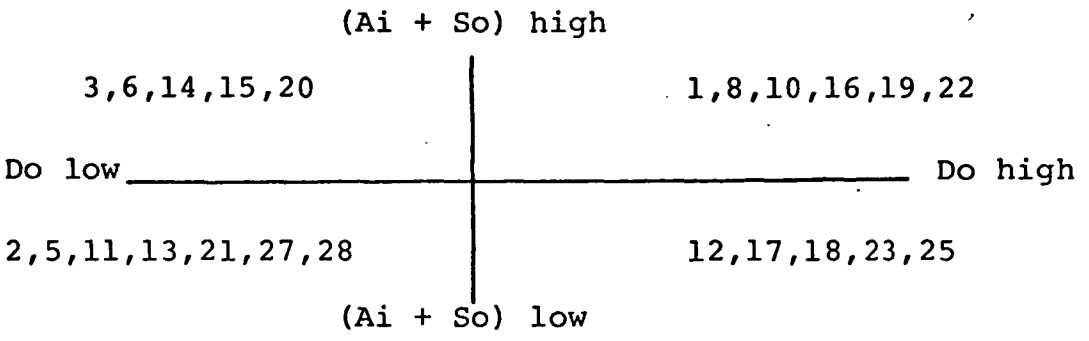


FIGURE 17

Multiple Interactions with Ranking on Performance Rating, Chemistry I, 1975

This appears to be promising as the four poor students, Nos. 25 - 28, fall in the low (Ac + Ie)/low Ai region. This is definitely to be expected given the characteristics of these three scores. In this low region it would be expected to find students unwilling to conform to a given learning situation, unable to act in an independent manner, and with low personal and intellectual efficiency. As a predictor of 'success' in the PSI course, high (Ac + Ie)/high Ai scores (which comprise the bulk of successful students) would appear to be quite high.

Other possible combinations have been attempted and the results shown against student distribution (see Figure 17).

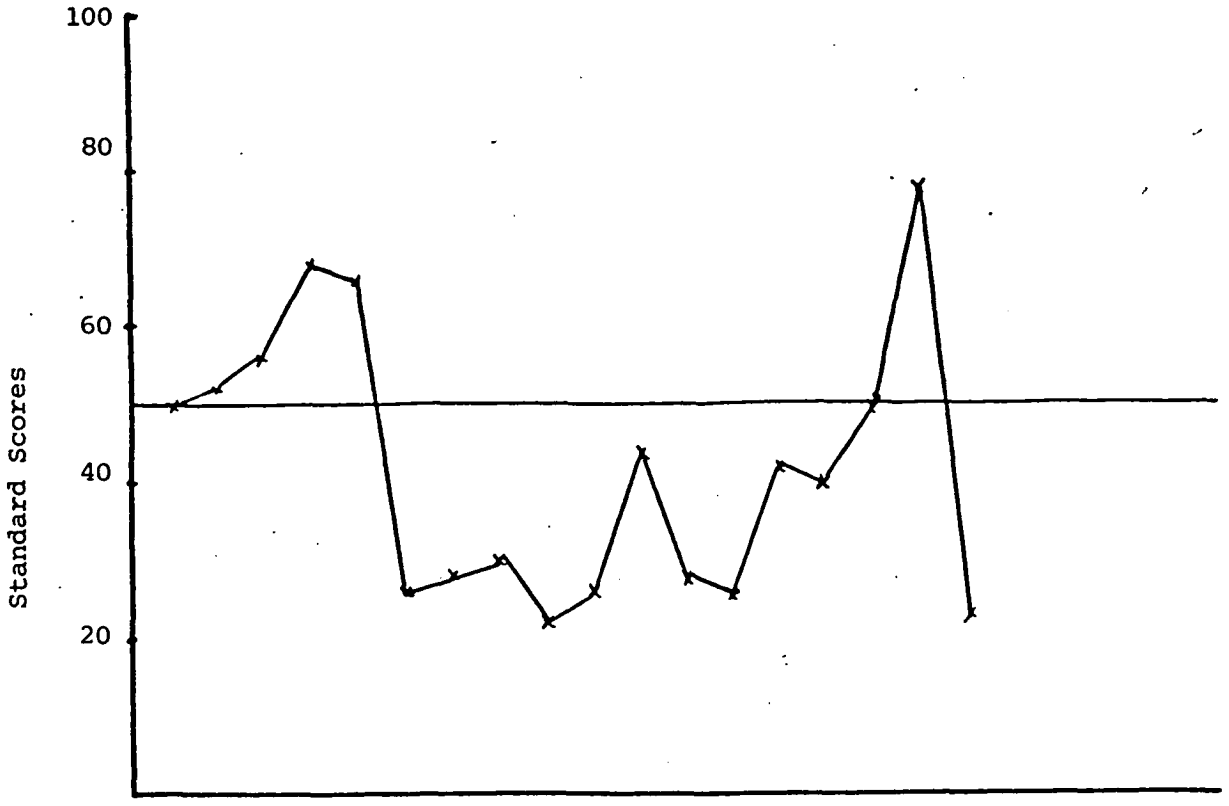
A more detailed process of prediction could be provided by interpreting the total overall picture for each student as represented by a plot of individual

CPI profiles rather than by considering single scores on selected particular scales. This is a much more difficult process. Suffice it here to record the plots of CPI ratings for students Nos. 25, 27 and 28, three of the failures or drop-outs (see Figure 18), and for students Nos. 1, 10 and 16 (see Figure 19) being three successful students. Each group of three contains one female and two males.

As can be seen, the three students at risk have similar CPI patterns, characterized by wide deviations from mean scores, usually on the low side. The three successful students, on the other hand, have reasonably stable patterns being just above or below the mean in all scores. Clearly then, this investigation of overall personality characteristics has potential for predicting possible problem students.

In considering the Biology I students, a similar approach to combining CPI scales can be taken. In a comparison of PSI Chemistry I with the more conventional Biology I course, possibly the most interesting here is the group of 19 students taking both Biology I and Chemistry I. The So and Cm scales combine to give a prediction value to $r_{So,Cm} = 0.53$ and a plot of student distribution is given (see Figure 20). As can be seen from this plot, students with low So and low Cm ratings perform worst in the biology examination.

Combinations of various other pre-test variables have been attempted and correlations for these with the



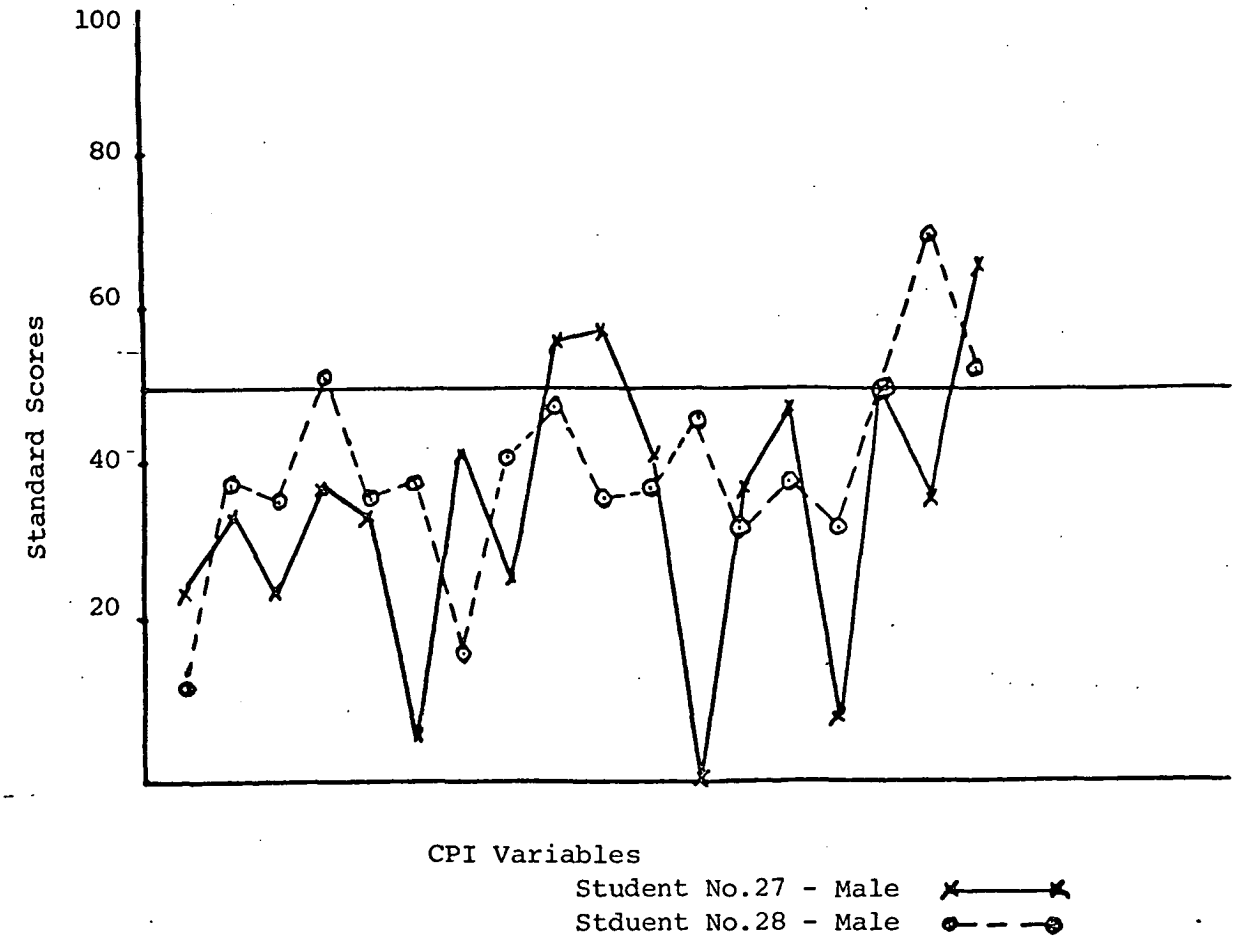


Fig. 18 Individual Student CPI Profiles (Students at risk)

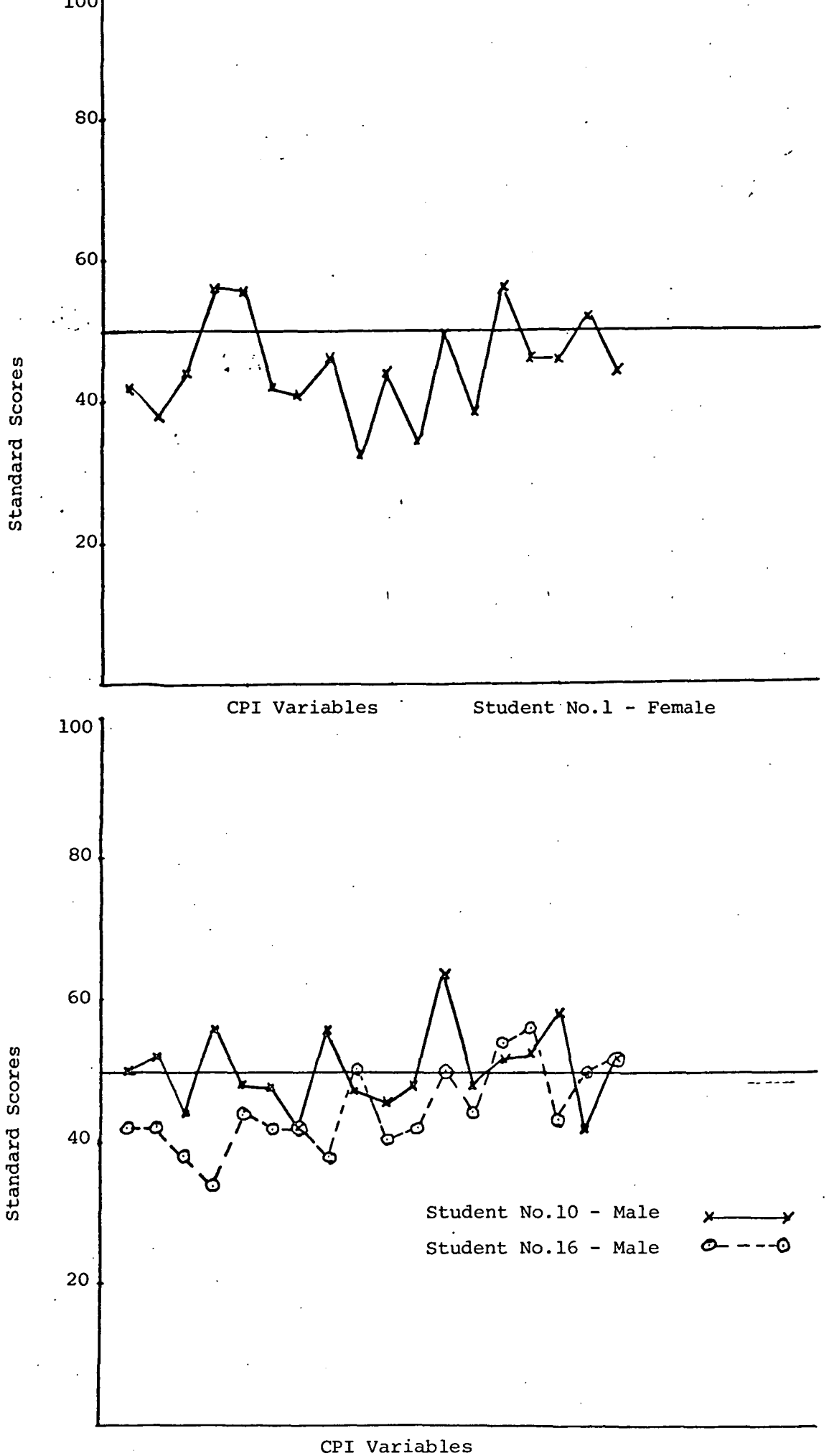
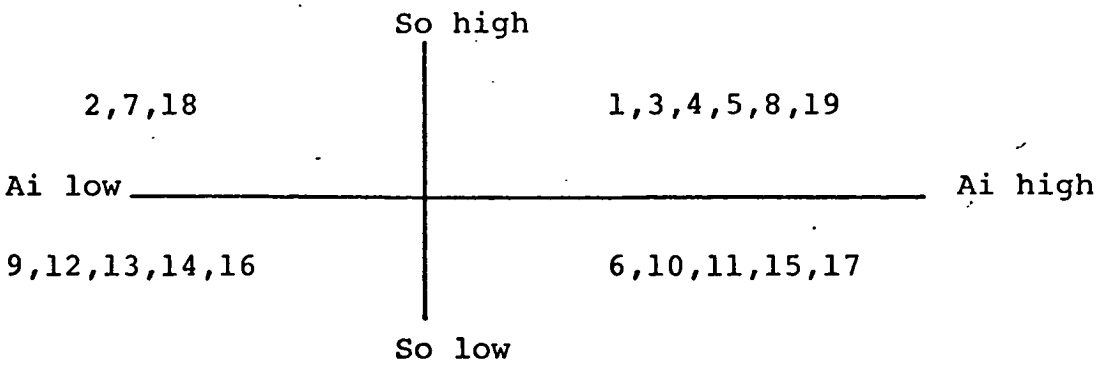
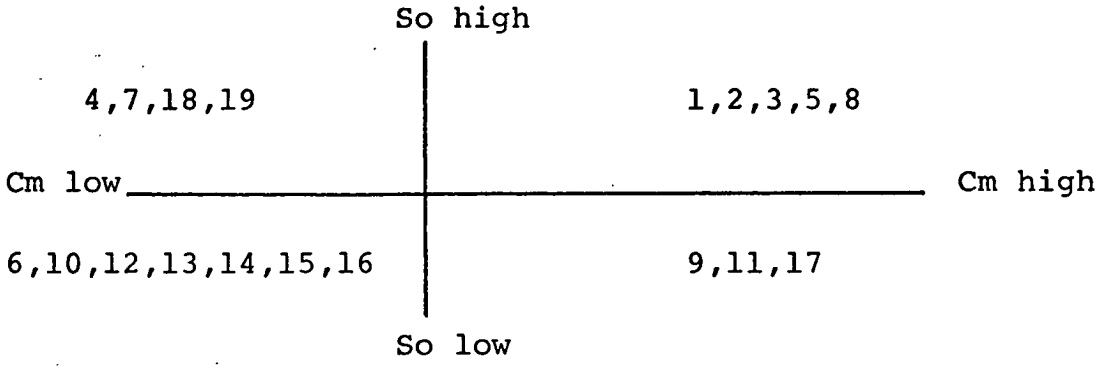
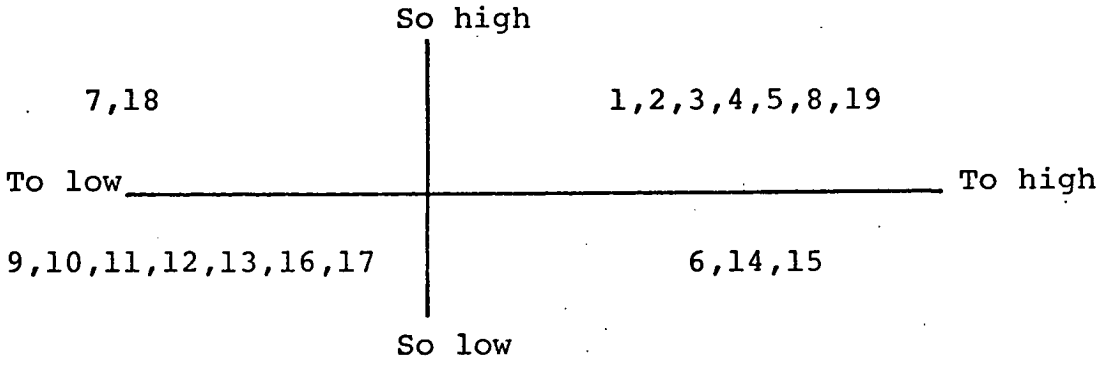


Fig. 19 Individual Student CPI Profiles (Successful Students)







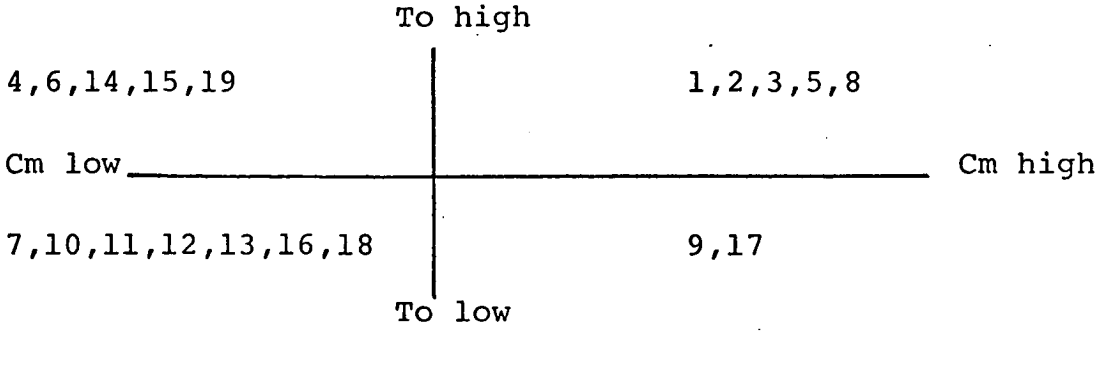


FIGURE 20

CPI Interactions with Biology Results, 1975

the biology result are given below.

$r_{So,Ai} = 0.56$ $\quad$ $r_{Ai,Ie} = 0.35$

$r_{Cm,Ai} = 0.47$ $\quad$ $r_{Ac,Ie} = 0.26$

$r_{To,Cm} = 0.50$ $\quad$ $r_{Ac,So} = 0.41$

$r_{To,So} = 0.52$

$r_{Ac,Ai} = 0.31$

Plots of student distribution over combined scores are given for the four highest correlations.

The failures in this biology course are denoted by Nos. 14 - 19. None of these combined scales gives a clear indication of guaranteed pass or fail in the Biology I examination - that is, for those students also taking Chemistry I. An extension of this type of correlation could be to the total biology class or to those not taking Chemistry I. However, this has not been attempted in this study.

Summary

From the investigation of the relationship between pre-test variables and performance in the Chemistry I and Biology I subjects, the main result was that the CPI variables offer a more promising predictive tool than the other individual variables. Nine specific results are listed, followed by a summary of their interpretation.

Results

1. There were no significant correlations between

pre-test variables and chemistry result on objective test.

2. Results on standard progressive matrices, and on the CPI variables, socialization and achievement via conformance, correlate significantly with the Chemistry I rating.
3. Results on Toledo Placement, speed and accuracy, and advanced AL (intelligence) correlate significantly with Biology I result for all biology students in the sample considered.
4. Considering only Biology I students not taking Chemistry I, flexibility, Toledo Placement, and student progressive matrices results correlate with biology result.
5. Considering Biology I students also taking Chemistry I, socialization correlates significantly with both chemistry rating and the Biology I result.
6. Students with both low socialization and achievement via conformance results were failures, drop-outs or incompletes in Chemistry I.
7. Students with high socialization and self-control scores were nearly all successful in completing Chemistry I in minimum time.
8. Several multiple interactions between CPI scales showed promise of being good predictors of Chemistry I success.
9. Students with overall CPI profiles

characterized by wide deviations from mean class scores were at risk in the Chemistry I course.

Interpretation

Overall, the results suggest that conscientious, responsible, and conforming students performed well in the PSI Chemistry I system. Given that the PSI course was highly organised and structured, even though student-paced, this means that students who could conform to the system performed well. A corollary to this is that students with low scores on the socialization and achievement via conformance variables were at risk in the Chemistry I course.

For Biology I there were no personality variables that correlated significantly with examination result. This confirms the finding of Goldbert (1972) with respect to conventional courses. However, the biology result correlated significantly with the advanced AL (intelligence) test, the Toledo Placement (TP) test, and the speed and accuracy test (S & A). The correlation with Toledo Placement, a test of science aptitude, and with AL could be expected as these measures have been used for college placement tests for some time. The speed and accuracy correlation is not as easy to explain, as the final examination was neither of the type nor duration to favour high speed and accuracy scorers.

An approach which provided a wider range of prediction about Chemistry I performance was to combine

pre-test variables to provide interactive predictors of performance.

Examination of the complete CPI profile of individual students has been tentatively proposed to give a prediction of students 'at risk' in the PSI Chemistry I course. On the limited number of profiles available it appears that students who fail or drop out are most likely to have a personality profile in which their CPI scores vary in any direction by large amounts from the mean. Successful students, on the other hand, have very regular profiles around a mean line. This considering of predicting possible 'successful' or, for that matter, 'problem' students in PSI courses using a psychological instrument shows signs of promise. It would have been the ideal situation to repeat the tests on 1976 students. A start was made in this, in that the new students taking Chemistry I in 1976 took the CPI test at the beginning of the course. However, problems arose in applying a similar PSI course in Chemistry I to 1975. Firstly, the instructor/researcher was overseas and a different staff member acted as instructor. Secondly, the Department of Chemistry moved into a new building and delays were experienced in the practical side of the course. Thirdly, a need to cut costs led to a drastic reduction in class time for tests to six hours per week from twelve. Finally, and probably worst, was the news delivered soon after the commencement of the semester that the college

may be closed and the students transferred elsewhere. The resulting loss of morale amongst students and staff guaranteed that the operation of the PSI course bore little resemblance to the 1975 course. It was considered pointless, therefore, to try to compare 1976 performance to 1975 as if both years were the same as far as the course was concerned.

However, a piece of related research, conducted on a national scale by another researcher, Fearn-Wannan (1975), provided interesting measures of divergent and convergent scores for the 1975 students taking the PSI Chemistry I course.

4.5.5 *A piece of related research - convergent and divergent thinking*

Fearn-Wannan (1975) tested students from Chemistry I classes in tertiary institutions in all States. He was carrying out a study to identify the nature of interactions between lecturers and various types of students. In the course of this study he tested the Chemistry I PSI class of 1975 for convergent and divergent thinking. These results were made available to this present research. Eight specific scores were correlated with the Biology I result, the Chemistry I test, and the Chemistry I performance rating (see Table 12).

TABLE 12

Convergent and Divergent Thinking Scores v Biology Result, Chemistry Rating and Chemistry Test Result

		Chemistry Rating n = 27	Biology Result n = 18	Chemistry Result n = 17
Mathematics Convergence	MC	.18	.30	.28
Verbal Convergence	VC	.27	.49	.05
Verbal Fluency	VF	.48	.30	- .04
Ideational Fluency	IF	.53	.65	- .10
Uses Fluency	UF	.50	.52	.21
Consequences Fluency	CF	.29	.20	.06
Uses Flexibility	UFX	.43	.52	.30
Consequences Flexibility	CFX	.27	.29	.27

When these results were sent to Fearn-Wannan, he gave the following interpretation:

> My first reaction to the figures you quoted in your letter was to query the type of assessment involved. By that I mean that I am interested in the proportion of questions that involved lower cognitive abilities (recall of factual information) compared with higher cognitive abilities (comprehension, analysis, etc.) The typical first year Biology exam usually contains questions that one would imagine would require convergent thinking (thinking along a given pathway to an agreed correct answer). However, I notice that Biology gives better correlations with some of the divergence scores. The following descriptions may prove useful.
>
> Convergence - as above.
>
> The questions used in the test of convergence were taken from the ACER B40 Intelligence Tests.
>
> It consisted of:
>
> 20 mathematical problems - MATH. CONVERGENCE
> 20 non-mathematical problems - VERBAL CONVERGENCE

Divergence - the ability to give a variety of responses to a given stimulus, e.g. write down all the possible consequences of humanity losing the power to reproduce.

TIME LIMIT : 3 MINUTES

Questions of this type were scored for FLUENCY - simply the total number of different responses.

They were also scored for FLEXIBILITY - the number of different categories of response, e.g. to the question posed above, one could expect the following responses:

a) increased sexual licence

b) baby food makers go broke

c) pram makers go broke

This scores 3 for CONSEQUENCES FLUENCY but, since responses (b) and (c) both involve the same concept (viz. the business difficulties of baby-supply companies), they together score on FLEXIBILITY - making a total CONSEQUENCES FLEXIBILITY score of 2.

TYPES OF DIVERGENCE ASSESSED (time limits imposed on each)

Verbal: e.g. How many words can you think of that begin with the letter Q?

Ideational: e.g. How many objects can you think of that have a flat surface?

Uses: e.g. List as many uses as you can of a brick.

Consequences: e.g. Write down all the possible consequences of humanity losing the power to reproduce. [p. 1-2]

Considering first the correlations with the Chemistry rating; for the sample size n = 27, a value of $r > .38$ is required for significance within the 5 per cent confidence level. As can be seen (Table 12) four of the divergent measures give reasonable correlations with the chemistry rating. This could be taken to mean that

performance in this particular PSI course was best among divergent thinkers in the student population considered. Caution has to be taken in extending this conclusion. The very nature of the PSI course - specified objectives, suggested study pathways, repeatable tests with agreed answers suggests that convergent thinking is more required on each unit. It might be argued that, in handling this PSI course, a student has to be divergent in his overall strategy and convergent in his approach to individual units. Since the chemistry rating is a measure of the overall performance it could be expected to show a high correlation with divergent scores.

In looking, however, at the correlations with the biology result, it is again the divergent scores that correlate well although verbal convergence is within the significant level required. On first view this may look an unreasonable result when it is considered that the biology examination questions are largely based on lower cognitive abilities. However, the students investigated are only those doing Biology I and Chemistry I, and these are not necessarily representative of all students taking Biology I. In fact, they are unlikely to be so because they have a wider science background and higher matriculation results than the other biology students and could well be expected to do better in the examination, ie. their better test scores were not necessarily due to divergency. This can readily be verified because the mean score of non-Chemistry I,

biology students on the biology examination was 47.5 per cent while those of the Chemistry I - Biology I group was 57.3 per cent.

Support for this can be gained from other sources. For the group of Biology I - Chemistry I students (n = 18) the correlation between Biology I result and chemistry rating is very high at r = .76 (see Table 10). Thus for the same group of students, good correlations between divergent scores and both chemistry rating and biology result is to be expected. This may also support a more generally held view that divergent thinkers ought to do better than convergent thinkers in the area of tertiary studies (Thompson, 1974). This conclusion must, however, be regarded as tentative without additional evidence. The highest Fearn-Wannan correlation with chemistry rating (IF) was combined with the two highest CPI correlations to see if this provided a better predictor of possible problem students than individual correlations. Because the group size considered in each case was different, it was necessary to recalculate single correlations for the group of 21 students for which all three scores, plus chemistry performance rating, were available. These were:

Rating v IF r = 0.45

Rating v Ac r = 0.42

Rating v So r = 0.41

IF v Ac r = 0.04

IF v So r - 0.08

The following combined correlations with chemistry performance were calculated from the above values

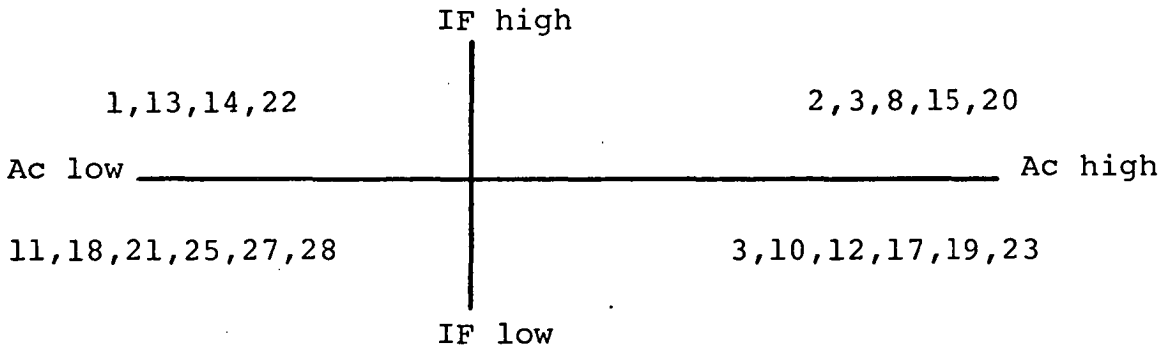
$r_{IF,Ac} = 0.06$ and $r_{IF,So} = 0.59$.

Both these values then give higher correlations than any individual correlation and hence are better predictors of performance in the PSI Chemistry I course.

The distribution of students on these combined scores is plotted (see Figure 21).

From the IF/Ac plot it can be seen that all the failures or drop-outs from the PSI course, viz. Nos. 24 - 29 fall in the low IF/low Ac region. A similar situation occurs for low IF/So students except for No. 28.

In considering the biology result, a combination of the high Fearn-Wannan predictor (IF) and the two highest CPI (for Biology I) predictors, So and Cm, were calculated for the 17 students taking both Biology I and Chemistry I for which values are available.



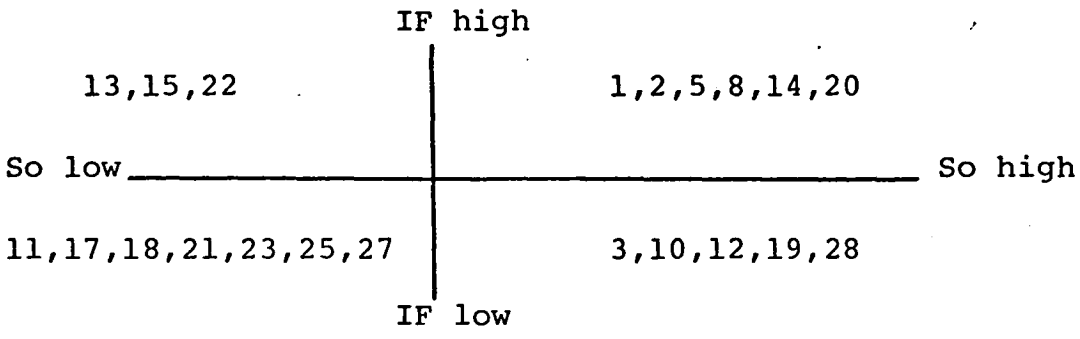


FIGURE 21

Fearn-Wannan/CPI Interactions with

Chemistry Performance

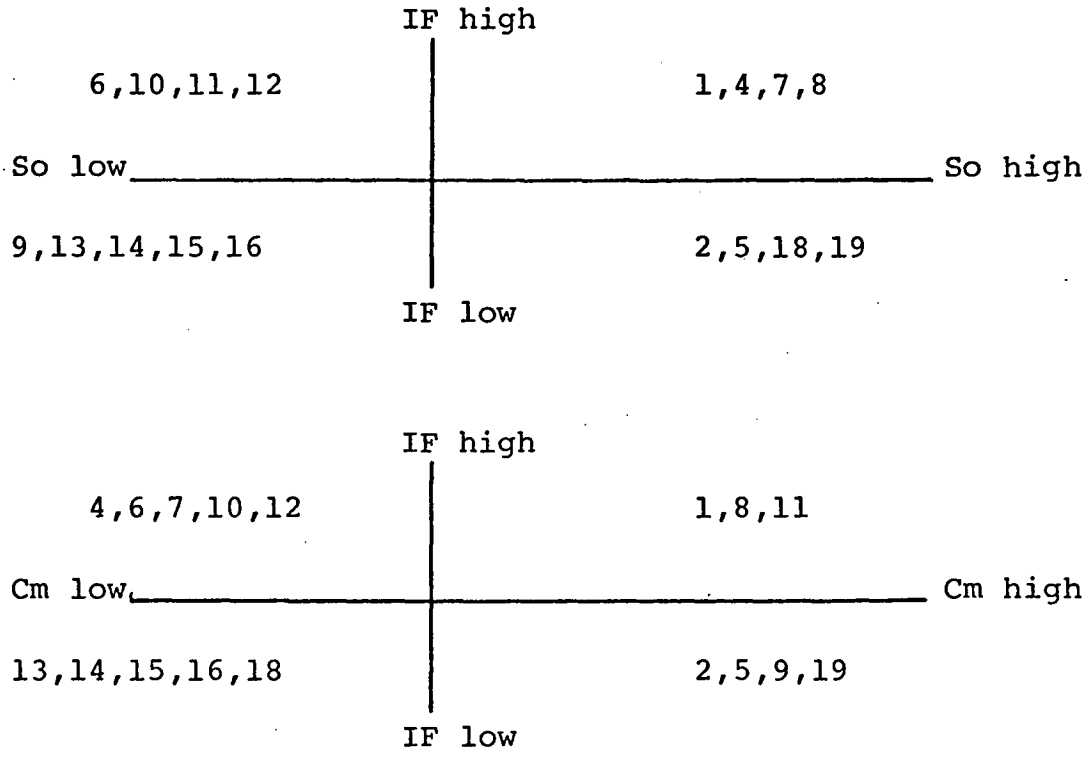


FIGURE 22

Fearn-Wannan/CPI Interactions with

Biology Result

The single correlations were:

Biology result v IF	$r = 0.48$
Biology result v So	$r = 0.53$
Biology result v Cm	$r = 0.55$
IF v So	$r = -0.03$
IF v Cm	$r = 0.19$

From these values the following combined correlations with the biology result were obtained.

$r_{IF,So} = 0.73$ and $r_{IF,Cm} = 0.67$.

Both are substantially greater than in the case of individual predictors. Plots of the Biology distribution against the two combined sets of scores are shown (see Figure 22).

Once again it can be clearly seen that students with low IF-low So or low IF-low Cm scores are, in fact, the students who did least well in the Biology I examination. Of course, it can also be noted (see Figures 21 and 22) that students who scored above the mean in Ideational Fluency (IF) alone, all either passed the Biology I examination or successfully completed the PSI Chemistry I course in minimum time.

Summary

The four main findings from an analysis of this related research were:

1. Students' results on Fearn-Wannan's tests of divergent thinking correlated significantly in the main with Chemistry I rating.

2. Similarly, divergent thinking results also correlated well with Biology I result, although verbal convergence also correlates significantly.
3. All Chemistry I failures and drop-outs have a combination of low ideational fluency and achievement via conformance scores.
4. Students taking Biology I with low combined scores in ideational fluency plus socialization, and ideational fluency plus communality did least well in the Biology I test.

For twenty-seven of the students taking Chemistry I, significant correlations of four criteria of divergent thinking were obtained with performance on the PSI course. This suggests that divergent thinkers will be successful on this PSI course. This can be confirmed in that the 'poor' chemistry students all had low scores on each of the divergent thinking criteria considered.

For the 19 students also taking Biology I the same four criteria of divergent thinking also correlate significantly with their Biology I result, although in this case one of the convergent thinking criteria is also significant. This finding is subject to limited interpretation as the Biology I class also contains many other students not tested in this way, and this particular sample is biased towards a strong science background.

When the high correlation scores from this thinking test are combined with CPI personality variables, some

interesting possibilities arise. Considering PSI Chemistry I performance students with low ideational fluency (a measure of divergent thinking) and low achievement via conformance (Ac) rating (a personality factor), all failed to complete the PSI course or dropped out.

For the Biology I students a combination of low scores on ideational fluency and socialization (So) gives the lowest six combined scores as the lowest Biology I results.

Clearly, the measures of divergent and convergent thinking need to be followed up in a wider study as they could well provide a convenient measure of student aptitude for different kinds of courses. It must be remembered that these and other correlations and predictions discussed earlier are made on the basis of a one-off study. Their generalizability to other PSI courses and even to future PSI Chemistry I courses is still open to question and needs confirmation by further studies.

In the final chapter the results of the evaluative research described in this chapter will be summarised, conclusions will be drawn, and suggestions for future study proposed.

CHAPTER V

SUMMARY

This report describes the design, development, and evaluation of a personalized system of instruction in a Chemistry I course at a college of advanced education.

In summarizing the work described in this thesis, it is appropriate to restate the three main aims of the project and to see how these were met by looking at a resumé of the research approach and the results and conclusions arising therefrom.

The three aims were:

Aim 1. To design and develop integrated, self-paced theory and practical courses in Chemistry I using the PSI technique.

Aim 2. To construct a course evaluation model and to evaluate the Chemistry I course using this model.

Aim 3. To investigate the relationship between personality and performance of students in the PSI Chemistry I course and a more conventionally taught Biology I course.

5.1 *Research Design*

The research design was based on the case study approach to the evaluation process. A multiple methods evaluation strategy was developed to implement the model, with a particular extension of the model to self-evaluation

by the instructor/researcher. The strategy involved formative evaluation in the initial design and development stages of the project. The second part of the strategy could be termed the illuminative stage in which major issues involved in the PSI course were identified and then focused on.

The issues identified as requiring special attention were course management, student attitudes, and student performance. To put a framework to the resolution of issues arising under each of these headings a series of questions were posed. The questions were formulated after consideration of the literature on PSI and modified during the course of the initial PSI trial course in 1974. The evaluation research methods used to provide answers to these questions were observation, feedback slips, analysis of course materials, questionnaires, interviews, outside evaluator assistance, student records, written comments, and a pre-test, post-test study of the relationship between personality and student performance.

5.2 *Evaluation Results and Conclusions*

In this section the research results are presented in point form followed, in each issue, by a summary of the conclusions reached.

5.2.1 *Course design and development*

a) Results

1. The problems in course design were similar to those discussed by other authors. These were:

i) difficulty in deciding course content;

ii) the time-consuming writing required;

iii) difficulty in pitching level of objectives to enable student mastery.

2. The use of feedback slips to obtain student opinion of course content was relatively unsuccessful because the student response rate on the slips became very low after the first few units.

3. The average number of tests taken per unit in 1974 was 1.62 and in 1975 it was 1.67. All but two students agreed that the tests for each unit were fair.

4. All students agreed or strongly agreed that the written study guides were generally satisfactory and adequate.

b) Conclusions

The process of course design and development can be identified as comprising the first stage of a formative evaluation strategy; utilizing the subjective views of people involved, feedback slips, student records, and test and item analysis to improve and rewrite the Chemistry I course. An illustrative example of this process was that used for rewriting the unit tests. Interviews with students, their responses on feedback slips, and the observations of proctors and the instructor identified that students had difficulty with essay questions, with variation of types and degree of

difficulty of test questions (in "identical" tests), and with test questions they felt did not directly test objectives. Item analyses of test results were used to confirm these observations and the tests were re-written. After the 1975 course all but four students agreed that the tests for each unit were an adequate assessment of their mastery of the material.

5.2.2 *Management*

a) Results

5. Different PSI learning centres were used in 1974 and 1975. Problems identified and resolved enabled the satisfactory design of a learning centre for future operations. Particular problems were noise, lack of an informal area, the need to separate study and test areas, the need to provide adequate space for proctors, security of materials, and safety.

6. The optimum test time that needed to be made available to students was four hours per week per student.

7. The proctors used were other undergraduate students who had previously completed Chemistry I. For all four proctors and in all nine categories of what makes a good proctor, students responded overwhelmingly that their proctors were satisfactory or superior. Further, 82.6 per cent of students regarded the assistance from

proctors as being important to PSI.

8. A student profile of a "good" proctor was one with a good grasp of the course, was patient and helpful, was easy to get along with and had the ability to explain problems.
9. Four hundred pages of typewritten materials were produced for each student, together with a substantial number of videotapes, films, and models for individual use.
10. There was low student usage of the range of audio-visual presentations and low to nil attendance at optional lectures.
11. One full-time instructor ran four concurrent PSI chemistry subjects in a total time of 12 hours per week, with assitance from demonstrators and proctors. In a normal lecture-laboratory-discussion course the instructor would have to teach for 24 hours with at least the same level of assistance.
12. The cost of operation per PSI student (for a class of 48) would be $408.75. The estimated cost per student, for 100 students, is $239.40. This compares with cost per student of greater than $280 (for 100 students) in a conventional lecture/tutorial situation. (Costs at 1975 levels)
13. The transfer of the PSI course to a second college campus was relatively unsuccessful because of lack of understanding at the second

campus about the nature and operation of PSI.

14. The operation of the PSI program was identified as a presentation, response, consequence cycle - usually on a weekly or part-weekly basis.

b) Conclusions

A feature of the PSI course was the demands that it placed on the management of a complex teaching-learning system. In this college the management was simplified by institutional factors, not least of which was the college commitment to resource-based study and to the encouragement of PSI courses by senior administrators. The introduction and testing of PSI was further helped by the fact that the college is a new institution, largely unfettered by course regulations and in a developing situation as far as staff, students, and courses were concerned. The introduction of PSI at an older institution, with fully developed courses and staff-student ratios already established, would be much more difficult and probably more expensive.

The management must, however, be based on a thorough appreciation of the underlying psychology of PSI. That is:

i) The use of written word was probably the easiest feature of PSI to adopt. Teachers are used to using books. But a trap faces the unwary. A new PSI 'textbook' can be just another test book. The written material must motivate, must inform the student clearly of expected terminal objectives,

and must direct him to alternative sources of information required to master the subject. It appears best to hand out materials in short cycles, or small amounts, thus increasing the encouragement and reward aspects of the present moment rather than overwhelm the student by the sheer volume of work, foreshadowed by handing out all the material at the commencement of the course.

ii) Students in the PSI course opted, in the main, for learning via written materials and verbal discussion, rather than audio-visual materials or lectures. In the college context, the poor attendance at optional lectures could, perhaps, be attributed to the environment that had been built up for the PSI course. A special PSI learning centre had been set up, complete with its own audio-visual area, and students were encouraged to use this for study, tests, and informal sessions around a coffee machine. The educational needs and social aspects of student/staff interaction appeared to be met by this scheme. This strengthens motivation and also provides for efficient management.

iii) From this experience and from other reports, that the maximum operating size of any one PSI course would be 100 students, requiring one instructor and 10 proctors. Even then the system would tend to

be 'depersonalized' and a compromise between cost efficiency and management would have to be made. For an even more cost-effective system at the college, experiments were conducted in running PSI courses in chemistry concurrently. Thus, the PSI learning centre was open for study and diagnostic testing for 12 hours per week, for students from four different chemistry subjects. The laboratories were likewise open to students from these four subjects for the same 12 hours per week on a student self-selection basis.

iv) The views of Keller (1968) and Sherman (1974) that the proctor function is essential to the toal PSI system was reinforced. Not only do proctors relieve the instructor of many of the more trivial aspects of the course but they provide a high level of interaction required by the system. It is important to select proctors carefully. There is considerable debate on whom the proctors should be but it is recommended that students who have just completed a course and who are only one step removed, conceptually, from the students they proctor, are in a better situation to identify student problems and to send students with difficulties to the instructor for tutoring. They can also build up a friendly relationship with students and this aids the mutual encouragement and reinforcement that is so essential to PSI courses.

5.2.3 *Student performance*

a) Results

15. Ten out of 14 students completed the course in less than one semester in 1974 and 21 out of 29 in 1975. Distribution of grades was similar to a conventionally taught Chemistry I course of 1973.

16. Of the 13 students who did not complete the course in one semester, three completed later in 1974 and four later in 1975.

17. Most students operated in the PSI course in a concentrated study pattern, many finishing by week 12 (of a 16-week semester).

18. The average number of tests taken per student per unit was 1.63 in 1974 and 1.67 in 1975.

19. Several techniques were used to overcome procrastination and to prevent drop-outs.

b) Conclusions

In terms of final results, students performed at least as well in the PSI Chemistry I courses of 1974 and 1975 as in the conventionally taught course of 1973. The major conclusion as far as PSI was concerned, however, was that it was possible to overcome procrastination and drop-out problem identified by other PSI researchers as being inherent in PSI courses.

Many so-called PSI courses require a student to finish the course within rigid time limits, say, a term or semester. Thus self-pacing becomes forced pacing. To be successful, a PSI course must allow the weaker

students time to pace themselves to master the course units. It was possible in this present case to minimize procrastination through early identification of problem students, through class and group interaction and mutual encouragement, through careful attention to design and production of materials, through provision of a drop-in learning centre, and through personal interaction of the instructor and proctors with students and each other.

5.2.4 *Student attitudes*

a) Results

20. Seventy-nine per cent of 1975 students, responding to a post-course questionnaire, rated the following components as being very important to the PSI Chemistry I course - clear specification of objectives, self-pacing, mastery, and multi-testing.

21. The students rated proctor assistance, self-study, and small-sized units of work important.

22. In responding to statements about their experiences in the PSI system, the students agreed or strongly agreed that: they learnt more; took advantage of opportunities to question proctors; PSI improved their study habits; they had increased contact with their lecturer; written study guides were satisfactory; tests were fiar and adequate to test mastery; they were integral members of

the course group; and that knowing the results of a test immediately was beneficial.

23. The students further thought that: the PSI course was not especially time consuming; the PSI course was more intellectually demanding than their other lecture courses; they would like to see more seminars; and that the PSI course compared favourably with their prior expectations.

24. The students strongly agreed that the PSI format encouraged their enthusiasm for chemistry and that they had become more interested in the subject as a result.

25. In a confidential questionnaire on their attitudes towards individual proctors, the students responded that all proctors
    a) had a good grasp of the topics,
    b) were willing to assist,
    c) were dependable,
    d) were willing to admit lack of knowledge,
    e) were appreciative of individual student's problems.

b) Conclusions

One of the important findings of this study was the fact that student attitudes towards the PSI course were extremely favourable. Both the trial group and the second class showed strong evidence for this. Of course this has to be looked at with reservations. It is to be expected

that students taking a new, innovative course would say they liked it merely because it was something new. Against this, however, is the fact that the favourable attitude of the students to PSI must enhance their chances of retaining the chemistry knowledge they had mastered during the course. This is particularly so as the students' attitude towards, and interest in, the subject of chemistry had increased during the PSI course.

A further conclusion was the overwhelming importance in the PSI system of removal of penalities for errors. Results of questionnaires, discussions, interviews, and observations pointed to the much less 'fear' approach to learning chemistry than is often observed in conventional examination systems. In this regard, each person involved in PSI obtains his reward from behavior of the others. Each one obtains maximum satisfaction when the other one's work is well done. It is a system of mutual reinforcement. The whip is never needed, motivation grows by itself with every unit passed, even for the slower-moving student. The passive acceptance of traditional lecture systems is replaced by an active student learning, student-staff interaction mix, without the fear and failure of the 'big-bang' examination. It generates in students a feeling of self-confidence in their ability, a better organization of their study habits, a completely new approach to learning - a learning reinforced by success.

5.2.5 *Student personality versus performance*

a) Results

26. Some Californian Personality Inventory scales correlated positively with performance in the Chemistry I PSI course. In particular, students who achieved via conformance or had a high degree of social maturity, integrity, and rectitude were identified as most likely to succeed.

27. For Biology I students, as a group, no CPI scale correlated highly enough to be significant. However, for the group of students taking both Biology I and Chemistry I, students with high socialization or communality scores were successful in Biology I. Sociability, therefore, was a common factor in achievement in both courses.

28. Of the other pre-test scores on non-CPI variables, the intelligence measure (PMS), science aptitude (TP), and speed and accuracy (S & A) could be used for predicting some measure of success in Biology I. However, only PMS correlated significantly with Chemistry I achievement.

29. The combining CPI scales' slightly stronger predicting correlations were obtained for students taking the Chemistry I course. For example, the correlation of $r_{Ac/So} = 0.50$ was

slightly higher than either of the individual predictors when considering performance in the PSI course.

30. Students with both high achievement via conformance (Ac) and sociability (So) scores were all successful in completing the Chemistry I course in minimum time. Similarly, a combination of high scores on both achievement via conformance (Ac) and a sense of well-being (Wb) also produced a group of successful Chemistry I students.

31. Individual CPI profiles showed that students 'at risk' in the Chemistry I PSI course were those students whose CPI scores varied in either direction by large amounts from mean scores.

32. From a related piece of research by Fearn-Wannan, measures of divergent and convergent thinking among the Chemistry I students were obtained. The basic result was that there was a correlation between divergent thinkers and performance in Chemistry I and in Biology I.

33. All Chemistry I drop-outs and incompletes had a combination of low ideational fluency (Fearn-Wannan) and achievement via conformance (CPI) scores.

b) Conclusions

Students whose personality enables them to conform to the system performed successfully in both the PSI Chemistry I course and in the more conventional Biology

I course. This result was perhaps to be expected. Rather unexpected perhaps was the finding that divergent thinkers were more likely to succeed in PSI Chemistry I than convergent thinkers.

5.3 *Future Directions*

There has been continuing debate about the merits and demerits of rival systems of education at all levels. Many attempts have been made to compare the effectiveness of various teaching methods, particularly on constant curricula. Typically, the statistical measurements adopted in such cases have shown that no one teaching method is significantly better than another. This has been particularly true in the field of tertiary education. In the field of PSI, for instance, many studies have been reported comparing the PSI system with more conventional teaching methods. This research has shown that PSI is at least as effective, if not better, than conventional methods in preparing students for final examinations. Robin (1976) was the first to show conclusively via a comprehensive review of research studies in the broader field of behavioral instruction, that such instructional methods are more effective than conventional methods. It is, however, an extremely doubtful proposition that such comparative studies can effectively distinguish between, for example, two such entirely different teaching methods as PSI and a lecture/final examination course. Comparative studies have usually used the final examination as a common measure of student performance or achievement. It is not even demonstrably obvious that such a measure is reliable or valid.

In fact, if it is remembered that PSI teaches for mastery whilst the lecture method for some lesser achievement, a final examination which only tests for end of course performance would appear to be a poor discriminator between them.

In criticizing such studies, however, it must also be borne in mind that the failures of PSI, if any, have not been reported in the literature. This is probably to be expected but until the critical literature on PSI has been built up, conclusions based primarily on 'successful' courses have to be viewed with reservations.

In the meantime, it is necessary to develop new evaluation tools for looking at innovatory courses in the human, rather than strictly statistical, sense. In this present research, use has been made of the more anthropologically-based case study or illuminative technique for investigating the PSI course in Chemistry I. While the methodology of this type of research is as yet in its infancy it is hoped that the triple approach of focusing, triangulation, and flexibility will provide some of the information and answers that educators need in order to pass judgments on courses and teaching methods. Focusing, for example, was used to concentrate on certain course issues on the basis of literature reviews and experience from preliminary trials. Triangulation was the process of using as many sources of data as possible to confirm findings about these issues. Flexibility allows changes to be made to the research strategy as the evaluation proceeds than is possible in fixed research designs. That is not

to say that the more 'hard-nosed' approach of control group and pre-test, post-test studies has to be abandoned. That is not so. There is a very strong place in illuminative research for such studies. Many issues can only be resolved by careful controlled studies and these should be used where necessary. This was illustrated in this present research in the pre-test, post-test study of personality versus performance in PSI.

In looking at educational systems, it must always be remembered, however, that teaching and learning are very personal things. Two teachers using the same methodology may operate within it in entirely different ways. Two students viewing the same videotape may come away with contrasting views. It should be obvious that what people put into or get out of an educational system may well depend on other factors than the teaching system used.

In this regard PSI has the advantage of being a system of instruction based on sound principles of learning and, providing the teacher is familiar with these and committed to the efficient management of the system, it should work. That this was not the case at the second campus involved in this study was because of the lack of understanding of PSI by the teachers involved at that campus.

What has been provided through the research described in this thesis is a model or starting point for self-evaluation by the instructor of the teaching/learning strategy he employs. A little of this should go a long way in improving an instructor's use of teaching/learning strategies such as personalized systems of instruction.

There are, of course, possible deficiences and problems in PSI and many questions remain to be answered. Some major considerations require particular mention. The question of mastery upon which PSI is based is one of these. What should the students have to master? In this Chemistry I course the objectives were formulated by the instructor on the basis that introductory chemistry can be taught as an hierarchical structure. Other instructors may well have formulated different objectives. If is possible, therefore, to challenge the curriculum on this basis. It is perhaps necessary, therefore, to look at curricula, at required preknowledge, at internal consistency, at truth, at relevance, and in terms of other criteria before passing judgment on the question of mastery. There is a lack of such questioning and research in this area, particularly in the field of tertiary education.

In the meantime, course designers who do their best to take into account all relevant factors could logically expect their students to master the work so designed, and PSI could be used as a method of mastery of such courses. The question of mastery of material equalling a pass in the subject probably boils down to a debate between the proponents of criterion-referenced and norm-referenced assessment. Suffice it to say here that in a Chemistry I course it can be expected that it is within the capacity of students to master certain material in readiness for taking further chemistry courses. If not, then logically they drop out of the PSI Chemistry I course and try something else.

Other questions on mastery arise. Is the student's mastery short or long term? One study reported suggests that

PSI mastery of a course is retained longer than that from a comparable lecture course. Here, however, people involved in PSI are not sure that long term retention of material is really necessary. It might be more important that the students, once having mastered certain material, can easily and quickly revisit any material he requires and quickly remaster it. Certainly this is probably true of proctors who, after having just taken a PSI course and then proctoring in it, should find it easier than students from similar conventional courses. The proctors also reinforce their grasp of the subject. Perhaps all students should proctor their subjects in order to learn them better. The old adage that you do not really learn until you teach may well be substantially correct.

A second major problem of PSI is that there is a tendency to use largely direct types of questions to test students' grasp of objectives. This could perhaps foster a mechanical approach to learning that is very little different from the memory-recall approach of students to final examinations. A major thrust of the PSI course in Chemistry I has been to write higher order (than pure recall) objectives in course units and then to test these with appropriate assessment questions. This has been reinforced by two particular strategies. The first of these are the review units which occur at regular intervals during the course. In these, students are required to write essays, solve problems, correlate information from previous units, and demonstrate their overall mastery of the course.

The second technique is the use of different types of

test questions and assessment techniques. A whole range of question types have been used with short answer, fill-in, multiple-choice, problems and essays predominating. But perhaps the most important for testing higher order objectives is the 'information array' type tests used particularly in some of the review units. Various pieces of information from previous units are distributed over a 7 x 7 matrix (information array). Students are then asked questions which require them to select information, pass judgements on statements, synthesise material, solve problems, and generally to operate at a higher order than pure recall. Again, the only proof of success of this technique lies in observation of the instructor and interviews with the students. What is needed is a controlled study of the use of such tests in comparison with conventional tests.

Another problem of major importance is the relationship between innovation and institutional factors. This also requires further study.

Where do we go from here? This investigation into one PSI course has been limited as all such short-term projects must be. Here some suggestions are made on possible added directions future research on PSI could take. These are posed as questions for which answers might only be obtained under controlled, experimental conditions.

a) How can students' progress through, and performance in, courses taught by PSI methods be adequately compared with the same courses taught by other methods?

b) What are the comparative gains made by students of

differing entry standards?

c) What are the problems of introducing PSI under neutral or adverse conditions? Such as, to a range of courses, to colleges where proctors are difficult or impossible to get, to other courses whose instructors are not versed in the basis of PSI, and so on.

d) What is the importance of removing penalities for errors and how does this affect the students' motivation and performance?

e) What are the long-term effects of PSI courses on students or on teachers? Do they suffer the familiar fate of loss of effectiveness through continued use that has been the lot of many other innovations?

f) What are the problems of transference of PSI courses? Can the materials be used in other institutions? Can other staff run existing PSI courses as well as the originator?

g) What of preknowledge of students? How should this be taken into account in designing PSI courses?

h) What is the retention both of type and duration of students after PSI courses as compared to other courses?

i) Do students have problems adjusting to self-study?

j) Are undergraduate student proctors essential or are other types of proctors satisfactory?

k) Can predictions of success in individual PSI courses based on personality characteristics of students be confirmed and extended to prediction for other PSI courses?

The answers to these and similar questions, and the continuing development of, and research into, personalized systems of instruction will be needed to provide instructors with the evidence they need on which to base their judgments about their selection of teaching strategies. This will, of course, be to the ultimate benefit of our students.

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APPENDIX 1

INSTRUCTIONS TO STUDENTS : CHEMISTRY I 1975

The study of Chemistry I has been organised for you on an individual basis.

The basic course content is divided into 19 reading units and 12 practical units. These units will come in a definite, numbered order and you must pass a unit test in each before passing on to the next unit.

A study area is available for you to work in, at set times, in the PSI Learning Centre, where a variety of written and audio-visual aids will be available. You may, of course, do your reading elsewhere.

There will be no compulsory lectures, tutorials or demonstrations. At certain fixed times there will be a lecture or demonstration available, which you may attend if you have completed a certain number of units.

Your teachers are Proctors, Tutors, an Education Technologist, and an Instructor. You will be assigned to an undergraduate Proctor who has volunteered to assist you and who understands the problems you face in this course. The Proctor will provide you with all your study materials except textbooks. The Proctor will give you unit tests and mark them. The Proctor's judgment is law, but if in serious doubt you may appeal to the Instructor for a ruling.

A Graduate Tutor will run the laboratory, supervise your practical work and test you in the practical units.

The Education Technologist assists with the course design

and evaluation and testing of the program.

The Instructor will select the materials, organise the course, construct the tests and answers, and pass final judgment on each student's progress. The Instructor will also provide the lectures and demonstrations and be available to assist Proctors, Tutors and Students.

The Instructor will present an overall view of the course on the first day of Semester I. This will be recorded on videotape and students who wish can view it at any later stage.

Unit Assessment

You must ordinarily obtain at least 17 marks out of 20 for each unit and verbally satisfy the Proctor about your mastery of the subject before continuing to the next unit.

You may try each unit test as many times as you wish. Failure to pass a test at the first, second, third or even later try, will not be held against you in any way.

Once you have completed Reading Units 1 - 16, Review Units 1 - III, and Practical Units 1 - 12, you will be granted a pass.

Final Result

The course this semester is divided into relatively small study units. Moreover, you are required to study these units in a definite, set sequence. It is important, therefore, that you review the whole semester course as a whole and note the various interrelationships that can be drawn between the topics studied. I would strongly suggest that you take the final examination because it is important that you have an

overall grasp of these chemical principles as they form the basis of your subsequent studies.

Your final grade will be assessed as:

a) PASS - completion of Units 1 - 16, Review Units I - III, and Practical Units 1 - 12.

b) CREDIT - completion of 2 extra Units

OR

obtaining 65%+ on a final examination.

c) DISTINCTION - completion of 4 extra Units

OR

obtaining 70%+ on a final examination.

d) HIGH DISTINCTION - completion of 6 extra Units

OR

obtaining 75%+ on a final examination.

Ordinarily you should have completed the course by the end of Semester I but you may extend the course into Semester II. Chemistry IB may not be commenced until you have completed Chemistry IA.

If you are still in doubt on any matters, come and see me and get an explanation for these.

I wish you all the best in your future studies. We (Instructor, Technologist, Tutors and Proctors) look forward to helping you to learn the fundamentals of chemistry.

(signed) Bill Donovan - Instructor

APPENDIX 2

STUDY GUIDE - SAMPLE

TASMANIAN COLLEGE OF ADVANCED EDUCATION
DIVISION OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY

CHEMISTRY IA

STUDY GUIDE

READING UNIT 4 : A model for chemical bonding

Introduction.

Bonding occurs when electrons occupy, for the most part, the region between the bonded nuclei. If we recognize the wave nature (or orbital picture) of electrons, we need to give spatial meaning to the Lewis diagrams we have been drawing.

Objectives.

On completion of this unit you should be able to :

1. Explain the electron-pair orbital model for molecular structures (Sidgwick-Powell theory).

2. Utilize the theory of hybridisation to provide an explanation for known structures.

3. Sketch electron-pair orbital diagrams, depicting the structure for any molecule in which a central atom is surrounded by 2, 3, 4, 5 or 6 electron pairs.

4. Explain the difference between sigma and pi bonds and sketch molecules which contain multiple bonds.

Suggested Approach.

1. Read BAR pps. 221-232. In order to more fully grasp the theory of hybridisation you should also read LEE pps. 27-35. During your

reading, it is important to keep in mind that hybridisation is only a theory which helps us explain, in a limited fashion, the known structures of fairly simple, covalent molecules. It is not a law of Chemistry.

2. You might like to view a film loop on hybridisation (A.V.No.). Another more advanced film (A.V.No.514) on Covalent Compounds is also worth viewing.

3. Before taking the Unit test you could use the following activities to check your progress -

Activity 1.

Write a brief explanation of the electron-pair model for molecular structures. If you are not satisfied with your degree of understanding discuss your problem with your Proctor or the Instructor.

Activity 2.

Problem 6 LEE p.40.

Activity 3.

a. Probs.9, 10. 12, 14 BAR pps.247-248.

b. Draw orbital occupancy diagrams, write the type of hybridisation and sketch structures of BeF_2, BF_3, CH_4, NH_3, H_2O, PCl_5 and SF_6.

Check your answers against LEE pps.30-34.

Activity 4.

Draw structures for C_2H_4, C_2H_2, CO_2, SO_2, CN^- & N_2. Label which are sigma and which are pi bonds.

4. Additional Reading.

BAM pps.222-230, mainly about hybridisation. At this stage it ought to be evident to you that a combination of the electron pair orbital model and the theory of hybridisation lead to a satisfactory model for chemical bonding in simple molecules.

More advanced theories, such as the molecular orbital theory will be discussed in more detail in Semester II.

APPENDIX 3

COURSE UNIT OUTLINE AND READING LIST

GENERAL CHEMISTRY - SEMESTER I

READING UNITS

1. The elements and the periodic table
2. Atomic structure
3. Covalent bonding
4. A model for chemical bonding
5. Trends in properties of the elements
6. s-block elements
7. p-block elements.

Review Unit I.

8. Resources and needs - Inorganics
9. The special role of carbon
10. Saturated hydrocarbons
11. Unsaturated hydrocarbons
12. Aromatic hydrocarbons

Review Unit II.

13. Alcohols and phenols
14. Alkyl halides
15. Aldehydes and ketones
16. Carboxylic acids and derivatives

Review Unit III.

OPTIONAL READING UNITS.

A. Consumer chemical materials
B. Synthesis
C. Inorganic Systems
D. Resources and needs - Organics
E. Ethers

CHEMISTRY IA

PRACTICAL UNITS.

UNITS 1-7

These seven units are designed primarily so that you will become familiar with the facilities and organisation of this Chemistry laboratory.

Unit 1. Determination of the concentration of an unknown acid.

Unit 2. Oxygen content of waters.

Unit 3. Observations on a chemical system.

Unit 4. Qualitative analysis.

Unit 5. Properties of Group II elements.

Unit 6. Synthesis.

Unit 7. Reactions of nitrites and nitrates.

UNITS 8-12

Each student will follow a custom-designed program consisting of a selection of FIVE Units from the following units A-H, designed to give the student practice in the experimental techniques of organic chemistry.

Unit A. Crystallization and Sublimation

Unit B. Melting points.

Unit C. Solvent Extraction

Unit D. Distillation

Unit E. Steam Distillation

Unit F. Chromatography

Unit G. Classification of unknown compounds

Unit H. Fats and oils; soaps and detergents

UNITS 13-17. - TO OBTAIN EXTRA CREDIT.

Students who have completed Units 1-12 may take up to five extra practical units from the following :

Unit I. Magnesium salts in hard water

Unit J. Washing efficiency

Unit K. Synthesis of $Cu(NH_3)_4SO_4.H_2O$

Unit L. Winning of a metal from its ore

Unit M. Fermentation of sugar

Unit N. The coupling of aromatic diazonium compounds : Dyes and Dyeing.

or from Units A-H above.

CHEMISTRY IB.

CHEMICAL PRINCIPLES - SEMESTER II.

17. Components and Properties of the earth's atmosphere
18. Molecular model of gases
19. The kinetic molecular theory
20. Molecular orbitals
21. Crystal structure

Review Unit IV.

22. The properties of natural waters
23. Solubility
24. Colligative Properties
25. Equilibria
26. Acids and bases, pH
27. Ionic equilibria (Hydrolysis, Buffers)

Review Unit V.

28. Kinetics
29. Heat and the First Law
30. Entropy, Free Energy and the Second Law
31. Work and Electrochemical Cells
32. Energy resources

Review Unit VI.

OPTIONAL UNITS.

F. A molecular interpretation of Entropy

G. Energy systems.

CHEMISTRY IB.

CHEMICAL PRINCIPLES.

PRACTICAL WORK

Practical Units 14-25 are compulsory. You can do them in your own time. The laboratory will be open Fridays 9 a.m. - 12 noon and Tuesday 5 - 10 p.m. You do not have to do the experiments in any set order, so check with your demonstrator about availability of equipment before commencing a unit.

Most experiments are directly related to theory Units and you may find it best to do them at the same time.

Optional practical units listed as projects F - J, are available to obtain extra credit.

Unit	Experiments
14.	Density of liquids by the pyknometer
15.	Molecular weight by vapour density
16.	Molecular size and Avogadro's number
17.	Victor Meyer - Molecular weight
18.	Packing in crystals
19.	Conductance
20.	Solubility Product
21.	Molecular weight by freezing point depression
22.	Buffers
23.	Hydrolysis of salts
24.	Solution calorimetry
25.	Reaction Kinetics and Catalysis

Projects

F. Photohydrolysis

G. pH and conductance studies of river water

H. Structures of compounds

I. Crystallisation

J. Electrochemistry

TEXTBOOKS

Prescribed :

BAR General Chemistry, by G.Barrow, (Wadsworth, 1972)

DPR Introduction to Organic Chemisty, by C.DuPuy and K.Rineheart (Wiley N.Y., 1967, paperback)

Reference :

MAC Experimental Organic Chemistry, by C.A.Mackenzie (Prentice-Hall, 1971, paperback)

DGH Chemical Principles, by R.E.Dickerson, H.B.Gray and G.P.Haight (Benjamin, 1970)

BAM Fundamentals of Chemistry : A Modern Introduction, by F.Brescia, J.Arents, H.Meislich and A.Turk. (Academic Press 1970, paperback)

LEE Concise Inorganic Chemistry, by J.D.Lee (Van Nostrand, 1965 paperback)

KIT Physical Chemistry, by S.L.Kittsley (Barnes & Noble, 1972 paperback)

ESY Organic Chemistry, A First University Course in Twelve Programs, by F.W.Eastwood, J.M.Swan and J.B.Youatt. (Science Press, 1972, paperback)

HSZ Organic Chemistry : A Short Course, by H.Hart and R.D.Schuetz (Houghton Mefflin, 1972, paperback)

ROC Fundamentals of Chemistry "A Learning Systems Approach" by R.O'Connor (Harper & Row, 1974, paperback)

APPENDIX 4

STUDENT QUESTIONNAIRES

(INCLUDING RESPONSES 1974, 1975)

Year 1975 Semester I

Dear Student

You have recently completed a Keller Plan course in Chemistry I. Your replies to earlier questionnaires have been most helpful and you are urged to complete this questionnaire as the last in the series.

Unlike earlier questionnaires you are asked to give your name. This is needed in order to compare your responses with other information about you and your progress in the Course. Please place your completed questionnaire in the addressed envelope provided. Your replies will be treated as confidential and seen only by me.

Yours sincerely

(Paul Northcott)
Educational Practices Unit

1. What is your name? Name .....

.....

2. What do you like about the Keller Plan (KP) course? Comment:

Self-pacing (14). Continuous assessment (5). More interesting (4). Covers material more thoroughly (4). Greater retention (5). Transfer of responsibility to student (2). Adaptability to suit individual (3). Good, varied and interesting course. Individual assistance available when needed (2).
Good, informal approach to the course, easy to meet new people. Liked small section of work at a time. Enjoyed the course.
Working by oneself a good incentive.
Course takes the pressure off the student, help available whenever needed.
Students get to know one another better - can talk during tutorials without being 'shot' by the tutor.
Even spread of work - no cramming (2).
Don't particularly like this form of education compared to traditional style. Do we have to do everything like the Americans?

3. What do you dislike about the KP course? Comment:

Possible for students to pass units without understanding

them fully.
Workload can be too demanding.
Knowing what everyone else was doing - too much pressure built up if lagging behind.
Some of the proctors were unnecessarily tough when marking.
Tendency to learn a little, fluke a test and forget all you knew.
No major changes necessary.
Constant pressure of steady work-pace can be gruelling, although results are better.
Like pass/fail grading, no H.D., D., etc.
Irrelevance of certain test questions to the objectives of the unit.
Objectives of the course are not always direct enough - they are misleading.
Testing time a bit restrictive. Would like to have had more than one unit at a time to study.
Too much noise in the PSI centre.
There are no lectures on generally difficult topics, therefore tutors repeatedly answer same questions to individuals.
Time-consuming when seeking advice.
Students in difficulty may be overlooked until too late.

4. Which type of assessment from those listed opposite do you most prefer.

End of year exam only .....
End of semester exam only ....
Continuous assessment and and of semester exam 4
Continuous assessment only 18
Indifferent 1
Other (please specify) .....

5. What is your attitude to the following features of the Keller Plan? (Please tick in relevant columns)

Mean x	4 Very important	3 Important	2 Neutral	1 Un-important	0 Very un-important
Clear specification of objectives on study guide 3.9	19	3			
Self-pacing facility 3.7	16	7			
Mastery level competence (ie. achieving very high scores on tests) 3.4	11	10	2		
Multi-testing, ie. the opportunity to repeat a test without penalty 3.5	13	9	1		
Selection of own study activities to fulfill objectives 2.8	3	11	8		
Assistance from proctor (student-tutor) 3.0	7	12	2	2	
Review units (ie. if applicable) 3.0	9	8	4	2	
Optional lectures, films, demonstrations 2.2	1	8	7	6	
Small-sized units of work 3.0	6	13	3	1	

Individual comments on choices made for question 5

I think that these facts above show the main benefits of the system and make it most enjoyable and successful for obtaining knowledge.

Optional lectures only needed if the reference books are not good enough.

The activities suggested were helpful, but the course allows for further reading, etc. Also open as to how to go about fulfilling them and pace.

With the units divided into a small number of objectives, it makes it easier to learn and remember different aspects of chemistry. You do not become confused with a large amount of material.

Sometimes the objectives are not clear. Thus, if the study activities are set out clearly, we have more chance of understanding what is expected of us. Generally the features of the KP are suitable.

I was pleased with the orientation of the course.

Mastery level competence must be high in order to pass each test, so each student must achieve high score. Small sized units of work probably enable more extensive testing on each unit.

If the unit is set out clearly then the student can find what he is looking for and study the relevant parts. Interest plays a great part as one tends to remember those units which are most interesting.

Mastery level competence - important if tests are fair and easy.

Sometimes assistance from the proctors is more useful than from the instructor as often the proctor had the same sort of problem doing the course and so can explain it better.

Most marked 'important' as I feel they are all important factors in the successful operation of the plan.

6. How do you react to the following statements? (Place a tick in appropriate column in each case)

Mean x	4 Strongly agree	3 Agree	2 Neutral	1 Disagree	0 Strongly disagree
The amount of material I learn/learned in the KP course is/was greater than in most other courses I have taken 2.8	5	11	5	2	
I was <u>not</u> always able to gain information or help about material I did not understand 1.7		8	3	11	1
I took advantage of the opportunity to ask questions of a proctor (student-tutor) 2.8	1	18	3	1	
I <u>never</u> took advantage of the opportunity to ask questions of the lecturer (instructor) 0.8				18	5
My study habits have significantly changed for the better as a result of doing the KP course 2.6	5	9	5	3	1
To profit from a KP course one has to have appropriate study habits <u>before</u> doing the course 2.1	3	7	4	7	2
I was unhappy to see other students completing units before me 1.6	1	4	5	11	2

	4 Strongly agree	3 Agree	2 Netural	1 Disagree	0 Strongly disagree
I object to having my tests marked by a proctor (student-tutor) 0.6		1		11	11
My contact with the lecturer (instructor) is/was greater than in other courses I am/ have taken 2.6	4	12	2	5	
The written study guides are generally satisfactory and adequate 3.3	6	17			
I would like to take another course (ie. one in the future) that uses the KP format 3.5	13	9	1		
The tests for each unit are fair 3.1	5	16	1	1	
The tests for each unit are an adequate assessment of my mastery of the material 2.9	6	12		4	
The units of work were too small and fragmentary 0.9			1	18	4
I felt I was an integral member of the group and course 2.95	4	14	5		
I retain more material from the KP course than from other courses 2.5	1	14	4	3	1

	4 Strongly agree	3 Agree	2 Neutral	1 Disagree	0 Strongly disagree
A KP course stifles creativity and individual initiative 1.04	1	2	2	10	8
The KP course encourages enthusiasm for the subject 3.0	8	10	3	1	1
Knowing the results of a test immediately after each unit is very beneficial 3.6	14	8	1		

7. How time demanding do you think a KP course is compared with a lecture/seminar course?

KP is <u>much more</u> time demanding 4
KP is <u>more</u> time demanding 7
About the <u>same</u> time is required 9
KP is <u>less</u> time demanding 3
KP is <u>much less</u> time demanding ..... -

8. Which do you consider is more <u>intellectually</u> demanding - a KP or a lecture/seminar format?

Lecture/seminar more demanding 5
KP more demanding 13
About the same 2
Don't know 2

1 abstention

9. Would you like to see occasional seminars incorporated and scheduled according to the 'slow' rate?

Yes 15
Unsure 6
No 2

10. How does the KP course compare with your expectations of the course?

Much better than anticipated	8
Better than anticipated	11
About what I expected	4
Disappointed with the unit	
Very disappointed with the unit	

11. Has your attitude towards the subject changed as a result of doing the KP course?

Very much more interested	5
More interested	12
Unchanged	5
Less interested	1
Very much less interested	

12. Any other comments? (Please include comments which you think will help explain choices made in the questions above and suggestions on how you think KP courses could be improved.)

I personally prefer the traditional style of education.

I think the occasional tutorial on aspects which everyone is having difficulty with is a good idea, especially in courses which are new work to the students (ie not a 'follow on' subject). The course is not as time-demanding as most of the work can be covered in college hours, so less study needs to be done at home - good move!

At present testing periods are Monday and Wednesday. As practical for part-time students is Tuesday night, a test period on Thursday would be more beneficial.

The study area and the lounge area should be further away from each other as noise from lounge area constantly disturbed my study. The only units I didn't like in this course were the review units because I hate writing essays. I hope organic chemistry becomes a PSI course before I have to do it!

An extremely interesting course.

I think it would be beneficial if tutorial groups could be arranged so common problem areas could be discussed in a group situation. The PSI system is a good way of learning. You make full use of the day and are actually learning from 9-5, rather than working late into the night trying to understand lecture notes.

The fact that you could work at your own speed and knew exactly how you stood with respect to the rest of the group was very good. It tended to make me put a great deal of effort into the subject and to enjoy it immensely, as compared with the lecture-tutorial subjects which I am doing which I begrudge time and would rather use it on Chemistry and Physics. The course was, in my opinion, a great success.

As students work at own pace and times, it is unrealistic to tie their test times, etc. to observed periods - a student may have to wait up to five days to officially ask a question. Clear that PSI requires presence of tutor/proctor more frequently to extract full benefit from the system. KP is dependent upon availability of proctors. If proctors are scarce (as in the case of Physics) students queue for 40 minutes or more to get advice or have a test marked. This doesn't give the KP or the student a fair chance.

QUESTIONNAIRE, NOVEMBER 1974 CHEMISTRY IB

Seven questionnaires were returned. A copy of the questionnaire is attached.

Question 2: 'Likes' were mainly the self-pacing aspect.

Question 3: Dislikes - more strongly expressed. One comment mentioned that a proctor was not on hand at all times [but should he be? PHN]. Another that course was "time-consuming";

and another that "I let my work suffer earlier in the year in favour of the other subjects, otherwise I quite enjoyed this type of programmed learning".

A sharp comment was made about fines which also acknowledged that this had nothing to do with PSI. See comments on fines given later.

Question 4: Assessment

Continuous assessment, only three; continuous assessment plus end of semester exam, four. However, there was a strong emphasis that the end of semester exam be 'optional'.

Question 5: Number of replies scored by column

Score:	4	3	2	1	0	Mean
Objectives	6	1				3.8
Self-pacing	5	1	1			3.4
Mastery *	2	2	1		1	2.6
Multi-testing *	4	2				3.6
Own study activities	1	1	5			2.4
Proctor assistance	1	3	2	1		2.5
Review Units	1	5		1		2.8
Optional lectures		1	2	4		1.5
Small units	3	2	2			3.1

* One respondent did not select an answer.

Comments

Four students added comments, viz:

"Some proctors were not conversant with the subject they were marking - others were excellent, at times better than the instructor."

"Optional lectures, etc. not important if clear specifications and references are given."

Question 7: Time demands

KP much more time demanding	0
KP is more time demanding	1
About the same time is required	2
KP is less time demanding	4
KP is much less time demanding	0

Question 8: Intellectual demand

Lecture/seminar more demanding	4
KP more demanding	1
About the same	0
Don't know	0

Question 9: Occasional seminars

Yes	2
No	4
Unsure	1

Question 10: Expectations

Much better than anticipated	1
Better than anticipated	2
About the same	4
Disappointed	0
Very disappointed	0

Question 11: Attitude change

Very much more interested	3
More interested	0
Unchanged	4
Less interested	0
Very much less interested	0

Question 12:

All seven students added comments here - some at quite some length.

Summary of comments

"At times proctor's knowledge not much greater than that of student - no other problems."

"KP approach has a flexibility which traditional approaches lack; it also eliminates the exam bogey - wish to continue with chemistry next year if course conducted in this format."

"The practicals "certainly leave something to be desired".

"Improved organisation of prac. work would go a long way towards making the subject as a whole more acceptable. More proctors, as at times I have waited half an hour to get a test marked."

"A very good method of teaching basics clearly and securely for later year (3rd) projects and theses; probably more appropriate."

"Small-sized units of work are most important I feel because most students readily absorb material in small study units more readily and confidently than lengthy and involved units, regardless of the difficulty of the subject matter."

"Re self-pacing - once I had fallen behind I didn't try as hard as I could have to catch up. However I had much other work anyway. I didn't get to see my proctor much although I felt I could have made better use of him. As for unit sizes, there were some units that could have been cut in half."

(The last comment was made by the student who marked the proctor's assistance as "unimportant".)

"It is important that these features of teaching chemistry continue - self-pacing facility, continuous assessment, specification of objectives, proctors always available, small-sized units of work."

"The KP course has many good points but one question must be raised. As the pass rate is high is this an inidcation that the course is too easy to pass? The subject matter is stimulating enough, but is the standard of education being lowered due to the manner in which it is presented and assessed?"

"What a priceless rhetorical question! Learning presumably has to be like traditional medicine; if it hurts or tastes bad then it must be doing me good. Hooray for the protestant, (work) ethic."

APPENDIX 5

PROCTOR QUESTIONNAIRE

How would you rate your proctor in relation to these attributes? Tick the appropriate column and row. You should comment only on a proctor who has assisted you on at least 5 occasions.

		PROCTORS			
		A	B	C	D
1. Mastery of course content	Superior	8	3		7
	Satisfactory	3	7	7	3
	Unsatisfactory			2	2
2. Grasp of course's orientation - i.e. overall topic arrangement and organisation	Superior	5	2	2	3
	Satisfactory	6	7	6	9
	Unsatisfactory			1	
3. Maturity of judgement	Superior	6	3	5	7
	Satisfactory	5	6	3	4
	Unsatisfactory		1	1	
4. Appreciation and understanding of your study problems	Superior	4	2	4	3
	Satisfactory	6	7	2	9
	Unsatisfactory	1	1	2	
5. Willingness to assist you	Superior	6	3	5	7
	Satisfactory	4	7	3	5
	Unsatisfactory	1		1	
6. Dependability	Superior	4	1	2	4
	Satisfactory	7	9	6	7
	Unsatisfactory			1	1
7. Articulateness	Superior	7	4	1	5
	Satisfactory	4	6	6	6
	Unsatisfactory			2	1

Appendix 5 (cont)

		A	B	C	D
8. Willingness to admit what he/she doesn't know	Superior	4	3	3	4
	Satisfactory	6	5	4	7
	Unsatisfactory	1	1	1	1
9. Proficiency in demonstrating practical skills (if appropriate)	Superior	2	2	1	1
	Satisfactory	1	3	4	2
	Unsatisfactory		1		
10. What particular strengths did the proctor(s) possess which were appropriate for his/her work as a proctor?	Comments:	Ability to assess students' grasp of subject (2) Knowledge and skill in explaining	Good grasp of course Very patient	Good grasp of course Quite patient	Very helpful Quite patient

General Comments about proctors in general:

Easy to get along with;
Good grasp of their subject;
Very willing to help and advise
In general, quite qualified and proficient in the task;
Personality influences their success;
Ability to explain problems (4)
Most had some experience in the PSI course or good background in chemistry.

Thank you for your assistance.

APPENDIX 6

UNIT FEEDBACK SHEET : SAMPLE ANALYSIS UNIT 1

UNIT 1

13 students did unit 1

3 students did test 1 once
3 students did test 3 once
2 students did test 4 once
1 student did test 4 twice.

1 student recorded 2 tests taken but did not give test number.

* (2 students gave date of taking test no. 2 (27/2/74 and 7/3/74) but gave no answer to "tests taken".
(1 student gave date of test (27/5/74) but no test number or "tests taken".

1 student took tests on 26/2/74; 6 on 27/2/74; 2 on 28/2/74.

The other 4 students recorded tests on 1/3/74, 3/3/74, and 7/3/74; and 27/5/74.

No. of tests taken

8 students did 1 test
2 students did 2 tests
(* see above)

Value rating of unit

1 student found the unit very interesting
12 students found the unit average or slightly above average in this respect;
2 students found the organisation and presentation very good

5 students found this good
6 students found this average or slightly above;
3 students found suggested activities very helpful
4 students found suggested activites helpful
2 students found suggested activities slightly below average
3 students found suggested activities of little help
1 student gave no opinion here;
2 students found the test very easy
3 students found the test easy
3 students found the test fairly easy
4 students found the test rather difficult
1 student found the test difficult.

(No two students who took the same test agreed on their rating on this point.)

Points liked

7 students found nothing to like in this unit.
Comments were:

a) Unit helped to classify and orientate ideas on periodic classification;
b) Clear presentation - easily understood;(3 students)
c) Unit tested understanding of concept intrinsic in periodic table;
d) Explanation relevant to electronic configuration is neat.

Points disliked

9 students found something to dislike in this unit.
Comments were:

a) "I didn't read a question properly and therefore had to do another test." (Fault in unit or student?)
b) Not enough detail or time given;
c) Maths (particularly index rules) hard to follow;
d) Unit straight out of text book - "parrot-like

repetition of objectives".

Other comments

8 students made no other comments.

Comments were:

a) Too much importance given to each question;

b) Suggested activities too limiting for types of questions asked;

c) Did not cover periodic table fully. Further study in future units?

d) Would like one or two problems worked out in full to demonstrate method and enable student to pinpoint own error.

APPENDIX 7

STUDENT PROGRESS CLASS CHART - CHEMISTRY I, 1975

STUDENT NO.	WEEK OF SEMESTER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1 2 1 1	3 1	4 5 1 2	6 2		7 2	RI 8 1 1	9 10 1 1	11 2	12 RII 2 1	13 1	14 1	15 16 1 1	RIII 1		
2	1 1 1 1	3 1	4 5 2 1	6 6	7 1		RI 8 1 1	9 10 11 1 3 1	12 1	RII 13 1 1	14 15 1 2	16 1	RIII 1			
3	1 3	2 2	3 1	4 2	5 1		6 4		7 3		RI 8 1 1	9 10 2 1	11 1	12 2		
4	1 2	2 3 2 3	4 5 3 1		6 4	7 RI 1 1	8 9 1 1	10 11 2 1	12 RII 1 1	13 14 15 1 1 2	16 1	RIII 1				
5		1 2 1 2	3 4 1 1		5 1			6 5			1 RI 8 2 1 1					
6	1 2	2 2	3 4 5 1 1 1		6 3	7 1	RI 1	8 9 10 1 2 2	11 1	12 RII 3 1	13 4	14 1	15 16 1 1	RIII 2		
7		1 1	2 3 1 1	4 5 2 1	6 3	7 3	RI 1	8 9 10 1 2 4	11 1	12 RII 4 1	13 4	14 15 1 1	16 RIII 4 1			
8	1 1	2 3 2 3	4 2	5 3	6 5	7 1	RI 8 2 1	9 10 3 3	11 4	12 RII 3 1	13 4	14 15 2 1	16 1	RIII 1		
9		1 1	2 3 1 1	4 1	5 2	6 2	7 1	RI 8 2 1	9 10 1 1	11 12 1 1	RII 13 1 2		14 1	15 16 1 1	RIII 1	
10		1 2 1 1	3 4 5 1 2 3	6 7 1 2	RI 8 9 1 1 1	10 2	11 2	12 RI 13 2 1 1	14 3	15 16 1 1	RIII 1					
11				1 2	2 2	3 4 1 1	5 1	6 3	7 1	RI 8 1 1	9 10 1 2	11 4	12 2	RII 13 1 2	14 3	

Units comp't Tests per un

Appendix 7 (cont)

STUDENT NO.	WEEK OF SEMESTER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
12		1 2 1 1		3 4 5 1 1 2	6 2	7 4	RI 2	8 9 10 1 4 1	11 12 3 2	RII 1	13 14 15 1 5 1	16 2	RIII 3			
13		1 2 1 1	3 4 1 2	5 2	6 2	7 1	RI 1	8 9 1 1	10 2	11 4	12 1	RII 13 1 2	14 2	15 2	16 RIII 2 2	
14	1 2		2 3 3 1	4 3	5 1	6 3	7 1		RI 1	8 9 10 11 1 3 1 1	12 RII	13	14	15 16	RIII	
15	1 3	2 1	3 4 1 1	5 1	6 5	7 2	RI 1	8 9 1 1	10 11 4 1	12 2	RII 13 1 1	14 15 1 1	16 RIII 1 1			
16		1 2 3 1 2 2	4 2	5 5	6 2	7 RI 8 4 2 2		9 10 3 2	11 1	12 RII 13 1 2 3	14 1	15 2	16 4	RIII 2		
17	1 1	2 3 2 1	4 1	5 1		6 5		7 1		RI 1	8 9 10 1 1 1	11 12 2 1	RI 13 1 1	14 2		15 16 RIII 1 2 1
18	1 1	2 3 2 1	4 5 3 2		6 4		7 RI 2 2	8 9 10 1 2 1	11 2	12 3	RII 13 1 1	14 15 16 1 1 2	RIII 1			
19	1 1	2 3 4 1	4 2	5 2	6 3		7 RI 1 1	8 9 10 1 1 2	11 12 2 1	RII 13 1 1	14 15 1 1	16 RIII 2 1				
20			1 1		2 3 4 3 1 1	5 1					6 6					
21	1 2	2 3 2 1	4 5 3 2		6 2	7 2	RI 1	8 9 10 1 1 1	11 12 4 2	RII 1	13 2	14 15 2 1	16 RIII 4 2			
22	1 2 2 1	3 2	4 3	5 1												
23	1 1	2 3 1 2	4 5 1 1		6 1	7 1	RI 1	8 9 1 1	10 11 3 4	12 1	RII 1	13 4	14 15 1 1	16 3	RIII 1	
24		1 3			2 1	3 1	4 2	5 6 2 2	7 2		RI 2	8 9 1 3				

Appendix 7 (cont)

STUDENT NO.	WEEK OF SEMESTER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
25	1 1				2 3	3 4 5 2 2 1	6 7 2 2	RI 8 9 10 11 12 1 1 1 1 1 3	RII 1	13 14 15 16 5 1 1 2	RIII 3					
26	1 1	2 3 1 1	4 2	5 1	6 1		7 2	RI 8 1 1	9 10 1 2	11 12 1 1		RII 13 1 1	14 15 1 2	16 RIII 2 1		
27			1 1	2 3 1 1	4 2	5 6 2 1		7 RI 1 1	8 9 1 3		10 2	11 12 1 1	RII 13 14 1 1 2	15 16 RIII 3 12		
28		1 3	2 3 4 2 1 1	5 2			6 1	7 1	RI 1	8 9 1 1		10 2				
29	1 2 1 1	3 4 1 1	5 3	6 7 1 3	RI 1	8 9 1 1	10 3	11 1	12 RII 2 1	13 2	14 15 3 2	16 1	RIII 2			

CLASS CHART : SEMESTER I, 1974

STUDENT NO.	WEEK NUMBER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1 2				2 3 2 1			4 5 1 1		6 1	7 2	RI 1	8 9 1 2	10 11 2 3	12 RII 2 1	
2					1 2	2 3 3 1	4 3			5 6 2 1	7 RI 3 1	8 9 1 2	10 3			
3		1 2	2 3 2 1	4 2	5 6 1 1	7 RI 1 1	8 1	9 10 1 4			11 12 RII 3 1 1	13 14 1 2	15 2	16 1	RIII 1	
4	1 1		2 3 2 2	4 3	5 6 3 1	7 1	RI 8 1 1	9 3	10 11 1 4		12 4	RII 13 1 2	14 15 1 3		16 RIII 4 1	
5									9 2	10 2	11 2	12 RII 1 1	13 4	14 2	15 2	
6	1 1		2 3 2 1	4 1	5 6 2 1	7 1	RI 1	8 9 1 2		10 11 12 2 1 1	RII 13 1 3		14 15 2 2	16 1	RIII 2	
7		1 1	2 3 1 1	4 1	5 1	6 7 1 1	RI 1	8 1	9 1		10 1					
8	1 1	2 2	3 4 1 2	5 2	6 7 2 1	RI 1	8 9 1 2	10 4	11 1	12 1	RII 1	13 2	14 15 1 1	16 2	RIII 1	
9	1 1		2 3 4 1	4 5 2 2	6 2		7 1	RI 1	8 9 1 1	10 4	11 12 4 1	RII 13 1 1	14 15 2 4	16 RIII 2 1		
10	1 1	2 2	3 4 1 3	5 1	6 2	7 RI 2 1	8 9 1 1	10 2	11 1	12 1	RII 1	13 3	14 15 2 1	16 RIII 2 1		
11		1 2	2 3 4 3	4 5 1 4	6 7 RI 1 2 2	8 9 3	10 11 12 3 1 3	RII 1	13 14 1 2	15 4	16 RIII 1 1					
12	1 2	2 2	3 1	4 1	5 2	6 7 1 1	RI 1		8 1	9 1	10 1	11 12 1 1	RII 13 1 1	14 1	15 16 2 1	RIII 1

Appendix 7 (cont)

STUDENT NO.	WEEK NUMBER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
13	1 2		2 1	3 4 5 1 3 1	6 7 1 1	RI 8 1 1	9 1	10 11 2 2	12 2						RII 1	13 14 1 1
14	1 2	2 3 2 3	4 3	5 2	6 7 2 2	RI 1	8 9 10 1 1 2	11 2	12 2	RII 1	13 4	14 1	15 1	16 4	RIII 1	
15	1 2	2 2	3 4 1 1	5 6 1 1	7 2	RI 1	8 9 1 1	10 11 2 1	12 1		RII 13 1 1	14 15 1 2	16 2	RIII 1		

APPENDIX 8

PROCTOR ESSAY

The first proctor who worked in the PSI Chemistry I course in 1974 and as a clerical assistant in the PSI study centre in 1975 was asked to write an essay about his experiences.

"My Experience as a Proctor in PSI Chemistry Courses, Tasmanian College of Advanced Education, 1974 - 1975

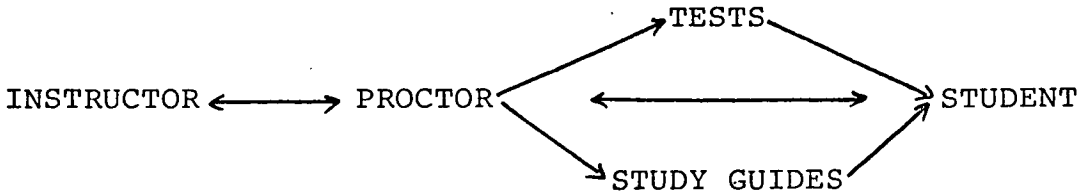
V.E. Cahne

What is the function of a proctor?

A proctor is an undergraduate who has previously completed the subject in which he will be proctoring. He is usually required to proctor for at least one three-hour session per week.

For a proctor's services, he is usually given either course credit or money - $3.00 per hour.

The following diagram illustrates how a proctor operates in a PSI course.



i) The proctor initially familiarises the student with the method of PSI instruction.

ii) The proctor issues study guides to the students and helps them master the objectives if help is required.

iii) When the student is ready to demonstrate his mastery of

a unit, the proctor selects one test from the four available and gives it to the student.

The proctor supervises him and the other students doing tests under examination conditions.

iv) The proctor marks the test with the aid of an answer booklet, in the presence of the student.

a) If the student obtains at least an 85% pass mark and also if the proctor is verbally satisfied that the student has mastered the unit, he then issues the next study guide to the student.

b) If the student "fails" the test, the proctor discusses the problems not answered and suggests ways of helping the student.

If the student is having considerable difficulties, the proctor recommends that the student should see the instructor for help.

c) The proctor also records the date on which each test was taken, the mark obtained and how many tests were taken for the student to master the unit successfully.

v) Another function of the proctor is to discuss with the instructor how the course is generally running. Proctors are directly linked with the students who give valuable feedback on tests, study guides, studying and testing conditions, and so on. Proctors must pass this information on to the instructor.

As can be seen the proctor is the key link in a PSI course. Consequently, I feel the proctor should have the following qualities.

i) He should be knowledgeable and have a mastery of the course content and orientation.

ii) He should be able and be willing to communicate with the students and be considerate and understanding about the problems of the beginning student. He should offer encouragement.

iii) He should be fair and just in marking tests - mature in judgment. A proctor needs to be tough with a student who tries to con him into passing a test. A proctor should seek the instructor' help.

iv) A proctor should be willing to admit what he doesn't know or is unsure about and direct the student on these occasions to consult the instructor.

v) Proctors should have some understanding of the theory and background of the PSI programme.

This may be achieved by:

a) Selecting proctors who as students have been through a PSI programme.

b) Having the proctors do a brief course on the PSI method.

<u>Below I have listed some important points that have characterised the proctoring in the Chemistry PSI course</u>

i) The proctors have been enthusiastic and willing to help students.

ii) There has been good social and academic interaction between students, proctors, and instructors.

iii) Proctors, in helping students, have reinforced their

own knowledge of Chemistry.

iv) Students are willing to act as proctors for either course credit or money - $3.00 per hour.

v) One possible "let-down" is that some proctors have shown inadequate mastery of the course material.

Below are listed my own views, on PSI as a means of instruction, which I have formulated from my experiences as a proctor

i) Students learn more in PSI than in lecture courses and PSI requires complete coverage of the material by the students. Also PSI usually requires more work by the student.

ii) Students like the individual pacing of PSI courses where they can progress at the rate they set themselves.

iii) There is always someone (proctor, instructor) available for about 10 hours per week, with whom the student can discuss (individually) their problems.

iv) Students prefer passing a subject by PSI methods as opposed to the lecture, "big bang" exam method and its side effects. In fact, students after doing PSI courses want other subjects to be converted to PSI courses.

v) Students enjoy the social interactions with other students, proctors, and instructors.

vi) PSI as a means of instruction is only appropriate where a mastery of course material is a prime aim.

Not all chemistry subjects are suitable to PSI programmes.

What have I gained personally from being a proctor?

i) A very enjoyable social and academic experience.

ii) Money.

iii) I am now designing and will be managing a PSI programme in Chemistry as part of my Bachelor of Education course."

APPENDIX 9

STUDENT DATA : PRE-TEST AND PERFORMANCE VARIABLES

CHEMISTRY I CLASS	Spced/Course	Tests per unit	Rating on Chem.	Biology	Toledo	CPI VARIABLES																		FEARN-WANNAN VARIABLES							
						Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe	AL	S&A	SPM	WKC	MC	VC	VF	IF	UF	CF	UF	CQF
M 1	6	1.47	41	28	40																		5	12	-	90	4	10	45	30	9	6	9	4
F 2	6	1.26	48	27	54	38	47	43	41	56	17	39	34	53	43	42	24	47	52	26	54	44	59	20	20	92	93	8	12	69	49	13	18	10	13
F 3	3	1.84	16	16	51	50	52	55	68	70	26	29	32	21	27	43	28	27	42	40	50	79	21	24	20	91	95	10	13	29	21	19	14	14	
F 4	7	1.52	46	25	40																			18	20	94	90	9	8	59	38	15	12	9	6
M 5	2	1.75	11	-	60	23	33	23	38	35	6	42	28	54	56	42	1	38	48	8	50	36	65	19	20	68	77	9	8	30	22	9	11	9	8
F 6	6	1.63	37	21	60	34	39	60	59	64	24	25	30	39	38	42	15	36	32	28	46	39	33	14	20	85	92	2	6	53	32	14	14	9	8
M 7	6	1.94	31	16	61	42	41	39	33	44	41	42	38	50	40	42	49	44	53	56	43	50	52	19	17	80	94								
F 8	6	2.26	27	22	61	56	55	57	60	70	35	35	38	27	38	42	33	36	55	38	39	59	38	20	20	82	95	8	7	63	59	18	33	16	16
M 9	5	1.21	41	-	51	50	52	45	57	49	49	42	54	49	46	48	63	49	51	52	57	41	52	24	16	89	97	10	8	51	29	8	17	5	14
F 10	8	1.47	54	33	65	41	39	45	57	56	42	41	47	31	43	33	60	38	58	46	46	53	44	16	20	85	88	10	10	67	44	32	14	31	10
M 11	6	2.00	30	19	59	48	41	51	44	49	14	50	33	41	52	43	8	40	48	34	57	39	42	16	17	92	94	12	13	32	26	6	5	5	3
M 12	4	1.75	23	19	69	40	62	49	46	63	29	44	35	54	48	48	26	49	53	19	54	39	47	18	19	91	-	7	9	45	31	17	19	13	19
F 13	5	1.63	31	26	69	59	47	57	48	81	47	39	38	43	41	43	37	41	42	50	36	56	36	19	20	75	91	7	10	58	29	12	12	10	12
M 14	5	1.73	29	14	52	40	46	37	52	41	61	48	43	50	52	50	31	42	58	43	50	61	42					6	8	47	15	4	8	4	8
F 15	6	1.36	44	30	36	43	36	40	36	53	37	44	43	46	52	35	28	43	55	32	54	41	44	16	14	77	97	7	11	35	36	23	19	11	13
F 16	6	2.21	27	30	55	33	33	28	32	25	44	48	55	56	52	43	46	45	52	46	54	47	53	18	20	82	88	8	12	53	34	9	13	7	13
M 17	4	1.47	27	-	43	35	60	51	52	63	21	48	29	42	44	45	17	36	56	30	50	56	57	22	18	91	96	9	10	46	25	6	10	6	8
F 18	6	1.73	35	22	57	27	30	36	36	30	10	50	32	46	41	33	5	31	48	30	50	53	41	24	20	79	92	5	9	31	35	22	17	16	15
F 19	7	1.52	46	27	72	27	33	53	48	50	47	31	49	47	31	48	28	41	40	34	54	53	53	18	20	85	95	7	7	35	43	23	19	12	13

Appendix 9 (cont)

CHEMISTRY I CLASS		Speed/Course	Tests per unit	Rating on Chem.	Biology	Toledo	CPI VARIABLES																		FEARN-WANNAN VARIABLES							
							Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe	AL	S&A	SPM	WKC	MC	VC	VF	IF	UF	CF	UF	CQF
M	20	1	2.16	5	-																						4	4	30	28	6	7	6	4
F	21	6	1.89	32	27	59	33	47	47	41	36	42	50	55	54	50	52	60	36	52	38	54	53	59	18	20	82	82	9	5	64	38	12	20	8	13
M	22	1	1.80	6	-	61	11	39	37	52	36	39	16	42	49	35	37	45	31	39	32	50	70	52	17	20	79	98	6	10	33	20	4	4	4	4
F	23	5	1.57	32	26	58	34	30	40	46	44	30	39	40	57	36	43	28	47	60	50	46	50	44	11	19	85	87	5	8	43	41	17	9	10	4
M	24	2	1.80	11	2	19																			2	0	82	92	3	2	0	6	2	8	1	2
M	25	8	1.78	45	-	33																			19	9	93	95	10	12	54	38	9	17	9	13
F	26	6	1.26	48	32	64	29	22	34	36	33	56	39	57	54	50	45	42	43	48	44	39	70	44	19	19	96	96	7	11	53	28	11	13	9	9
M	27	5	1.36	37	15	57	52	44	53	52	60	34	46	47	50	33	62	26	51	29	34	50	39	55	6	16	76	78	4	4	44	24	9	11	7	6
M	28	3	1.36	22	18	53																			17	11	82	89	9	10	34	6	13	6	10	
F	29	8	1.78	45	32	76	31	44	51	55	58	53	41	43	44	48	42	46	43	55	60	61	70	36	23	20	92	92								

F = 15 (14)

M = 14 (9)

Appendix 9 (cont)

BIOLOGY I CLASS (non PSI Control Group)	Biology	CPI VARIABLES																						Toledo
		Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe	AL	S&A	SPM	WKC	
1	14	24	44	38	55	61	7	31	15	43	48	32	-	34	58	7	61	44	41	9	15	-	91	30
2	24	41	36	45	39	44	44	33	40	32	48	38	55	43	60	54	54	64	50	14	20	90	92	51
3	8	49	44	55	50	72	40	48	55	39	50	37	46	34	50	54	43	59	47	7	20	86	91	17
4	14	58	57	51	60	50	44	48	35	36	46	45	45	40	37	32	43	39	62	14	10	88	94	36
5	27	31	47	34	62	58	30	25	38	21	31	35	46	29	40	28	39	76	53	17	20	95	87	44
6	23	50	39	51	50	39	56	48	43	49	55	43	51	54	62	42	54	79	44	16	20	96	90	29
7	18	29	39	47	57	56	47	20	38	31	43	32	37	36	48	32	43	76	30	14	20	87	85	27
8	17	26	28	36	46	42	40	39	51	40	41	28	37	31	58	30	43	67	41	23	16	93	86	55
9	20	41	41	45	53	58	42	41	42	36	41	42	60	43	60	38	54	59	62	20	16	-	93	29
10	22	52	58	62	62	58	51	52	43	42	62	50	42	47	55	50	46	59	53	16	15	86	94	44
11	26	4	33	43	54	49	39	40	35	34	31	38	49	38	51	36	43	76	60	13	20	86	83	69
12	19	68	30	64	55	56	51	41	47	36	59	30	42	38	60	56	71	73	50	18	18	85	83	40
13	23	36	36	53	71	50	42	41	49	44	48	57	55	45	60	38	39	73	41	14	20	92	81	30
14	19	26	44	51	52	47	42	29	49	58	41	45	46	29	42	40	36	56	50	19	19	92	84	60
15	11	31	33	43	50	53	37	35	51	31	31	35	51	34	48	24	36	47	53	13	19	79	86	20