A Method of Evaluating Psychomotor Tooth Preparation Skills in Preclinical Dental Programs

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ABSTRACT

Preclinical and clinical tooth preparation is an important and significant aspect of a dental student's education. The associated procedures rely heavily on the development of particular psychomotor skills. The most common format of instruction and evaluation in tooth preparation at many Dental Faculties, emphasizes the product (tooth preparation) and associates performance with characteristics of this product.

This integrated study examines which skills should be developed and how a course of instruction can best be structured to develop the necessary skills.

The skills which are identified are those necessary for tooth preparation are selected from a psychomotor taxonomy.

The purpose of evaluating these skills is identified. Behavioral objectives are set for student performance and the advisability of establishing standards of performance is examined.

After reviewing studies related to the most suitable learning strategy for dental psychomotor tasks as well as articles on instructor effectiveness a model is proposed. A pilot project at the University of Toronto, based on this proposed model is described.

The paper concludes with a discussion of the implications of this proposed model.
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CHAPTER I

INTRODUCTION TO THE STUDY

There is assumed to be "a continuum of knowledge acquisition ranging from no proficiency at all to perfect performance" and the degree of competence attained by a particular student (emphasis added) is what is assessed. Competence is conceived of as being a continuous characteristic. There are at most, ambiguous suggestions that a single point exists at which competence becomes incompetence.

(Glass, 1978)

Introductory Statement on the Purpose of this Study

With passages such as the quotation above, Gene V. Glass, a provocative psychometric specialist assailed the designation of standards and cut-off scores as related to criterion-referenced testing. Nevertheless, standards are a fact of life and are established in practically every human endeavour for the protection of society. Foods and drugs have standards of purity, professions have standards of competence, and education has standards of excellence.

For many years, dental schools have provided their graduates with standards which will ensure an acceptable level of dental health care delivery. These standards reflect the knowledge, professionalism and treatment skills society expects. Since evaluation of student behavior is ultimately linked to standards of practice there have been numerous studies devoted to evaluation in the dental literature. Currently there is considerable interest in the
evaluation of clinical and preclinical performance. One skill common to both clinical and preclinical performance is that of tooth preparation.

Preclinical and clinical evaluation is necessary to assure society that health care providers will be competent. This means that a competent health professional meets and/or exceeds acceptable standards of performance. In Canada, the National Dental Examining Board (N.D.E.B.) is a regulatory board composed of examiners and consultants from each province. These individuals are recommended by Provincial Licensing Boards for their teaching and/or clinical expertise. The N.D.E.B. has no formal affiliation with either academic associations nor with the dental profession at large. Candidates trained in other countries who wish to practice in a Canadian province may complete a course of study at a dental faculty or alternatively pass the written, preclinical and clinical examinations in the N.D.E.B. The N.D.E.B. certificate is recognized by every provincial licensing college with the exception of British Columbia. Since graduates of accredited dental faculties receive their N.D.E.B. certificates automatically, for all intents and purposes, the dental faculties also function as regulatory bodies. Therefore, there is an accountability aspect to preclinical and clinical evaluation applicable to both the dental school as well as the practice sector.
Description of Procedures to be Followed

Traditionally, dental students are instructed and evaluated during the first and second year in theory, basic sciences and preclinical skills (Boyles, 1982). Preclinical skills are techniques which require the integration of knowledge and psychomotor exercises (Figure 1). These exercises are performed on manikins which simulate a patient's oral and dental anatomy.

In the latter half of the second year as well as in their third year of studies, students are introduced to the treatment of patients. These experiences with patients are termed clinical sessions or clinical practice. The fourth (final) year is devoted almost exclusively to various types of clinical practice. These clinical skills are a complex mixture of cognitive, affective and psychomotor skills (Weinlander, 1979; Shugars et al., 1981; Potter et al., 1982). The need for a study for evaluating these skills in the context of dental schools includes the following:

All evaluation should be accountable and in turn good evaluation makes the educational system accountable. One author (Wickline, 1971) provides an example of educational accountability (or apparent lack of it) in recounting the conversation between the late Senator Robert F. Kennedy and Harold Howe who was then Commissioner of Education in the United States.

Senator Kennedy asked Commissioner Howe, "What have you accomplished with the billion dollars
Preclinical and Clinical Psychomotor Skills Related to Major Domains

Figure 1
that you got for elementary and secondary education last year?" In reply, Commissioner Howe began listing the number of books that had been purchased, the amount of money that had been expended for teachers, the amount of money that had been used for the purchase of equipment and materials, and so on. When finished, Senator Kennedy was quite impatient, and asked, "What happened to the children? Do you mean that you spent a billion dollars and you don't know whether they can read or not?"

Accountability to the student and the public is the basis for the evaluative procedure of candidates who seek admission to a dental school. This procedure requires consideration of a person's grade point average, the results of a Dental Aptitude Test and a personal interview. These measures are used as predictors of cognitive, affective and psychomotor abilities to minimize the number of failures. Since dental courses are specialized and have limited application outside the profession, a dental student has little chance of receiving credit towards other programs if he were to seek transfer to another course of study. It is only natural that a student who fails a course in Dentistry will very aggressively appeal his or her standing to the faculty. Several studies have indicated that preclinical and clinical evaluation is weak in reliability and sometimes the measures are not valid (Lilley et al., 1968; Hinkelman and Long, 1973; Houpt and Kress, 1973; Olson and Comet-Epstein, 1979; Patridge and Mast, 1978). In order to substantiate a pass or fail it is essential that preclinical and clinical evaluation be a reliable and valid procedure.
Recognition of inadequate progress at specified intervals is useful for the application of remedial instruction. This can only be accomplished if evaluation is of such a nature as to reflect inadequacies of quantity and quality as well as process and product. This need for evaluation which will assist with remediation is particularly required for psychomotor skills (Eisner, 1979).

Students require accurate feedback to know how to correct their skill development (Hinkelman and Long, 1973; Houpt and Kress, 1973). Studies have indicated that misleading knowledge of results hampers, if not extinguishes, a student's progress. For this reason also, clinical and preclinical evaluation studies are necessary (Mackenzie et al., 1979).

To have an indication of instructional effectiveness, clinical and preclinical evaluation which is accurate and definitive is required (Denehy and Fuller, 1974). Often, a student's lack of progress may indicate problems with the instructional format. These areas of weakness when identified can be adjusted.

Decreasing budgets resulting in decreased staff require that courses of instruction be efficient teaching vehicles. A measure of efficiency in a course is available if evaluation is reliable, valid and practical (Daggett et al., 1979).

The importance of studies in preclinical and clinical evaluation to the private practice of dentistry has several
implications. The advent of dental insurance has effected changes in the delivery of dental care (Eisner, 1979). The practitioner is now accountable not only to the patient in regards to competence of treatment, but also, to the third party which is involved in payment for the service. Extensive treatment procedures require authorization in advance by the insurer. This is provided by the practitioner on what is termed a "treatment predetermination form". These "predeterminations" are scrutinized by a dental consultant who determines the insurer's liability. At times, a consultant will question either the necessity of the type or the amount of treatment recommended. There is considerable hostility on the part of members of the profession to this type of review. The professional practitioners argue that this review challenges their professional judgment, without the consultant clinically examining the patient. As a result, various dental associations have initiated studies into what constitutes clinical competence. This has developed into peer review procedures with documentation of standards of performance (California Dental Association, 1979). These regulatory procedures would be enhanced by an ability to evaluate clinical performance more accurately than at the present.

In the United States of America there is a strong movement to establish Professional Standards Review Organizations. These P.S.R.O.s are, in some cases, legislated mandatory and attempt to control continuing competence in a profession (Bailit et al., 1974).
The problems faced in Canada are similar. The fact that competence was assured at the time of graduation does not assure the public that competence will be maintained. A health professional can become less than competent due to illness, impairment, or lack of currency. For these reasons the licensing boards of several Canadian provinces presently insist on evidence of adequate continuing education on a five year basis before a practitioner can be relicensed. This trend appears to be expanding into other provinces of Canada (Martinello, 1983). If a greater degree of accuracy of clinical evaluation could be demonstrated, then the competence of health professionals to serve the public could be judged more readily.

In summary, the need for studies in clinical and preclinical evaluation has implications in dental education in accountability to the public by graduating students who acquire the required standards of treatment. Students on the other hand desire accountability through defensible evaluation on their admission to a dental school, during their progress and in situations when they are declared a failure. A dental school's administration also requires accountability for instructional effectiveness and efficiency.

The need for studies in clinical and preclinical evaluation also has implications in the practice sector as related to third party insurance coverage and peer review procedures.
Overview of the Topic

In reviewing clinical evaluation historically, (Eisner, 1979) points out that the public and the profession believe that licensing protects health care consumers. Later he states,

while licensing has played the major role in the continuing effort to protect the public, it too often has tended to institutionalize a lack of accountability to the public.

Even in the early days of dental education there were professional standards which had to be met for licensure (Gullett, 1971). The clinical standards were usually assessed on a global basis and in a subjective manner.

A clinical evaluation form at the University of Toronto in the 1950's assessed the following student attributes (Kreutzer, 1950):

- professional decorum -- 10
- instruments and equipment -- 10
- planning and practice -- 10
- knowledge and skill -- 70

This same author identified some of the problems of clinical evaluation when he stated the following:

When the human element as well as practical skills have to be judged, the problem of marking becomes difficult. At no time is it as simple, as for example, the scoring of a written examination of a mathematical nature which may involve only a single mental operation and has an answer which is either right or wrong. Marking in clinical dentistry is also inevitably subject to inconsistencies of human judgment and the vagaries of personal impressions or prejudices of the instructor.
In the 1960's the academics in dental faculties were beginning to question the validity and reliability of clinical and preclinical evaluation. A review of clinical medical teaching (Daggett et al., 1979) quotes a 1967 study in which the why, what, how, when and who of evaluating dental students by instructors was discussed. This search for better indicators of preclinical and clinical evaluation continues to this day (Nash et al., 1981).

Why were dental educators so late in recognizing and correcting problems of inconsistent measurement and evaluation? Possibly part of the answer to this question was offered earlier in the section which explains the rationale for this thesis. More of this question may be answered by the fact that the professional literature has reflected an increased sensitivity on the part of the professions to consumer demands and accountability to society.

**Indication of A Need for Change**

Many current studies in the health science literature indicate a need to redirect student instruction. Morgan (1980), in reporting a performance-based approach compares five, old and new, educational premises in medical education. These were specified by a medical education research group at the University of Vermont and were found to be based on false assumptions (Appendix I). One of their five arguments is presented below:
The old educational premise holds that a core of knowledge should be taught. No one learns anything in the same time; some students are quicker, others slower at learning. Yet colleges and medical schools have made the body of knowledge and the time taken to study it identical in all respects. Failure is therefore built into the present system. A new educational premise would emphasize eliciting a core of behavior from the student rather than rote memorization. By beginning with simple tasks, students would learn by doing and would see the immediate relevance of their learning.

Morgan continues to describe the benefits of a performance-based approach and how it would benefit students in other disciplines. Figure 2 illustrates medical actions and performance traits proposed by Morgan and applied to Bloom's taxonomy. This illustrates that there are alternatives to the traditional approach of instructing and evaluating medical students in clinical skills. The same is probably true for dentistry.

Recently, some medical educators have addressed themselves to the following questions (Downing, 1978; Maatsch, 1978; Sirotkin and Whitten, 1978; Sprafka, 1978):

- How well does a clinical experience in the dental or medical school reflect the performance expected of a competent practitioner?
- How valid is the preclinical experience as a measure of readiness for students to treat patients clinically?

Maatsch (1978) in a study titled "Toward a Testable Theory of Physician Competence," compares five test formats
Figure 2. Performance traits and medical actions.

(After Morgan 1978)
which measure seven clinical skills. He concludes that "a
knowledge/performance model as well as a process/skill model
must be examined in order to assess clinical competence.
The knowledge/performance model proposes that knowledge
about basic science and clinical information is different
from, but a part of the ability to perform medicine (Figure
3). Barrows et al. (1978), analyzed the clinical methods of
medical students and physicians in a longitudinal study
decided that,

It is certainly evident from this study that
clinical competence cannot be viewed as a
stable, uni-dimensional trait . . . whatever
technology is developed for evaluation of the
clinical encounter, it must provide separate,
valid assessment of the various components of
the encounter, and must do so in a sufficient
number of cases to overcome the low reliability
of such measures across problems.

Although the medical clinical encounter has some
differences from dental clinical sessions there are many
commonalities. Because preclinical and clinical skills
consist of a complex mix of subskills it would appear
necessary to "provide the separate valid assessment of the
various components" which Barrows mentions above.

A need for change in Canadian dental schools is
demonstrated by the topics of the recent conference sessions
of The Association of Canadian Faculties of Dentistry
(A.C.F.D.) which deal primarily with clinical evaluation.
A.C.F.D. is examining the feasibility of a study which will
examine the possibility of a new clinical construct (Eisner,
Figure 3. MAATSCH'S KNOWLEDGE/PERFORMANCE MODEL

EVALUATION OF KNOWLEDGE ABOUT PROCEDURE (A) + EVALUATION OF ABILITY TO PERFORM PROCEDURE (B) = EVALUATION OF PHYSICIAN'S CLINICAL COMPETENCE (AB)
1979). Eisner defines an evaluation construct as, "a theoretical ordering or arrangement of individual concepts into an integrated whole". Further he states, "In developing a new (clinical) construct the skills of quality discrimination and clinical judgment must be considered."

Formerly, dental schools were accredited on structures and processes of dental education. The future trend will be on quality of patient care and the clinical competence of the graduates (Eisner, 1979).

Statement of the Problem

Clinical and preclinical tooth preparation skills have traditionally been evaluated by means of an assessment of the product of performance (Patridge and Mast, 1978; Shugars, 1981). The operator performs the procedure on the patient's tooth (clinical) or on a typodont tooth in a manikin (preclinical). This procedure results in a cavity form which adheres to principles prescribed by G.V. Black (1936) over sixty years ago (Appendix II). Although these principles have been in existence for some time, their interpretation at times results in ambiguity. For example: the first principle describing cavity depth is specified as "through the enamel and 0.5 - 1.0 mm into dentin."

Since enamel varies in thickness on different teeth and because it also varies in thickness on different aspects of the same tooth there is a potential for different opinions (Figure 4). This is partially due to the inability
of the operator to discern where the layer of enamel has been penetrated. This problem is present to even a greater degree in preclinical exercises because the typodont teeth used, have been, and continue to be manufactured as one homogeneous mass. Only within the last few years have typodont teeth with a differential enamel-like layer been available for preclinical exercises (Figure 5). This problem of depth definition presented difficulties in communicating the correct depth of cavities as well as evaluating what constituted the ideal depth of cavity preparation.

Similarly, the other principles of cavity preparation contain concepts which are not defined with explicit criteria. To the student inexperienced in tooth morphology, function and stresses this appears confusing and ambiguous.

Problems also exist with evaluators (Patridge and Mast, 1978). Mackenzie (1982) identified the following sixteen variables in evaluators which are detrimental to consistency:

1. Checkpoint ambiguity.
2. Faulty memory.
3. Incomplete coverage of dimensions.
4. Unspecified exceptions.
5. Untrained estimation of size.
6. Unstandardized aids to judgment.
7. Unspecified methods of observing.
8. Incomplete operational definition.
9. Unsystematic inspection.
10. Discrepancies in visual acuity.
11. Degrees of leniency.
12. Inadequacy of verbal definitions.
13. Inadequate communication with non verbal examples.
14. Unrecognized ambiguities in definitions.
15. Differences in background.
16. Differences in mental processing.
Figure 4
Natural Tooth Enamel - Variation in Thickness
Figure 5

Typodont Tooth Construction

A. Most Commonly Used - No Enamel Layer

B. New Design - Illustrating Simulated Dentin (Core) and Enamel
These variables contribute to low reliability in product evaluation.

This thesis consists of an integrated study which examines, through a review of literature, the problems associated with evaluation in these dental skills. This study will therefore, have the following objectives:

1. To identify the purposes of preclinical evaluation of psychomotor tooth preparation skills.
2. To identify the sub-skills within this area of instruction.
3. To set behavioral objectives required of the learner.
4. To identify the products or processes which should be evaluated.
5. To specify criteria for the product and process which can be evaluated.
6. To determine the evaluative methodology.
7. To define the characteristics which evaluators should display.
8. To demonstrate feasibility of approach in a pilot study.

This model will be titled "A Method of Evaluating Psychomotor Tooth Preparation Skills in Preclinical Programs."
The research was carried out and categorized into sections relating to the above stated objectives. The review of literature in Chapter II is presented according to sections which address these stated objectives also. In Chapter III the organization of the presentation of the model is again consistent with these sections thus assisting the reader to follow the rationale for establishing the model.

Limitations and Assumptions

Tooth preparation may be classified as to type depending on whether it is intra-coronal (within the crown), extra-coronal (on the crown exterior), intra-radicular (within the root) or some combination of these types (Figure 6). Although there are differences in anatomy as well as principles related to the particular type of preparation these variations will not impart a difference to the evaluation model. Therefore, this thesis will describe a model based on an intra-coronal preparation only.

In order to define this topic further the author has chosen to avoid the clinical aspects while concentrating on the preclinical area.

There are some similarities and some differences when considering preclinical and clinical
Figure 6
Classification of Cavities
evaluation (Figure 1). However, by eliminating the clinical aspect we will remove a number of variables. These variables are in the patient's physical and personality characteristics as well as the operator's cognitive and affective behavior associated with clinical performance. This elimination of variables should add to the clarity of the thesis presentation without losing relevance to the clinical situation.

Although preclinical procedures require some prior knowledge by the operator of what he/she is attempting to do, it will be assumed that this cognitive function is well understood by the operator.

It is also assumed that the equipment and instrument design is appropriate to efficient manual manipulation. Objects which are not properly designed would impart a characteristic of clumsiness.

A final assumption made is that students will be instructed and evaluated in these psychomotor skills in conjunction with cognitive and affective factors. This is essential that students although performing on typodonts will be prepared for treating patients. Patients require consideration in order that they enjoy a relaxing comfortable environment. Students should be capable of acceptable communication skills.

**Definitions**

To promote better communication it may be helpful to
define certain words and concepts which will appear in this presentation. Since this thesis deals with aspects of evaluation, psychomotor skills as well as preclinical modes of instruction, definitions of relevant terms are provided under these headings:

**Definitions Related to Evaluation**

**Measurement** - is a process of determining the extent of some characteristic associated with an object or person. For example, when we determine the length of a room, or weight of an object we are measuring (Mager, 1962).

**Evaluation** - is the act of comparing a measurement with a standard and passing judgment on the comparison (Mager, 1962).

**Formative Evaluation** - is an evaluation whose purpose is primarily that of providing feedback to the student and facilitating learning. This occurs during the training sessions (Lutz & Mast, 1975).

**Summative Evaluation** - is an evaluation whose purpose is for certification of a level of competence (Lutz & Mast, 1975).

**Reliability** - is a characteristic of evaluation which assures consistency of evaluation. Therefore, if an evaluation today will be the same as an evaluation tomorrow or on a subsequent day the evaluation is said to have reliability.

**Validity** - is a characteristic of evaluation which assures that the judgment and measurement of performance is in effect judging and measuring what it is supposed to
measure. There are various types of validity such as: face validity, content validity, construct validity, empirical validity, logical validity and process validity.

Objectives - are descriptions of intended outcomes. They are descriptors of the standard we would like students to achieve or surpass (Mager, 1962).

Norm-Referenced Evaluation - is the judgment of performance which compares the performance of one student to another (Mager, 1962). This comparison of performance allows a teacher to rank students from the lowest to the highest achiever.

Criterion-Referenced Evaluation - occurs when we compare a measurement not with other measurements, but with some objective standard (Mager, 1962). (For a comparison of characteristics between criterion-referenced and norm-referenced evaluation see Appendix II).

Rating Scale - is a continuum which represents the level of achievement reflected through measurement.

Score - is the symbol, usually a number or a letter which identifies a particular position on the rating scale.

Definitions Related to Psychomotor Skills

Scannel (1975), in describing Harrow's Taxonomy of the psychomotor domain offers the following definition.

Skilled Movement - is a degree of efficiency, grace and skill in performing complex tasks requiring movement and physical abilities. The movements required in athletics and dance are examples.
**Skilled Response** - is one in which receptor-effector-feedback processes are highly organized both spatially and temporally. Spatial temporal patterning, the interplay of receptor-effector-feedback process and such characteristics as timing anticipation and the graded response are thus seen as identifying characteristics of skill (Sage, 1971).

**Abilities** - are inherent, given characteristics of an individual (Fleishman, 1972). (Eleven psychomotor ability factors have been identified).

**Definitions Related to the Mode of Instruction**

**Preclinical Dental Instruction** - refers to instruction which students receive to develop the integration of knowledge with practical techniques. These exercises are usually performed on manikins which simulate a patient's oral and dental anatomy. Preclinical techniques are taught primarily in the first and second year at a dental faculty. Candidates who successfully pass their preclinical techniques are considered ready for patient treatment.
CHAPTER II

REVIEW OF THE LITERATURE

Introduction to the Review of Literature

The nature of this study consists of a synthesis of previously conducted research. Therefore considerable importance was placed on the sources of the information, the degree of relevance and overall quality of the material selected for review.

The literature related to fine motor performance was sampled mainly from Psychological, Medical, Dental, and Educational literature. This review was initiated originally as an independent study.

Studies relating directly to preclinical and clinical evaluation were obtained primarily from the Journal of Dental Education, Journal of Medical Education and Journal of Dental Research.

References related to tooth preparation skills were obtained from textbooks and manuals which are considered appropriate for current undergraduate instruction. All sources are primary unless indicated otherwise.

The studies are arranged and discussed under headings associated with the objectives stated in the thesis problem section.

The motivating factor in this research was the need to revise a course of instruction which the author co-ordinated at the University of Toronto between 1975 and 1980. This
resulted in a model of instruction which is described in Chapter III. The thesis model not only contains aspects of the model installed at the University of Toronto but also features which are improvements based on experience with this pilot project.

**General Review of the Literature**

There are numerous references in the literature as to what the purpose of preclinical evaluation should be.

**The Literature Related to the Purpose of Preclinical Evaluation**

Lutz and Mast (1975) draw a distinction between summative and formative evaluation. Summative evaluation is used to measure terminal competency and would be used for promotion, certification or licensure. Formative evaluation's purpose, in contrast, is primarily to provide feedback to the individual learner. This results, "in a profile of student strengths and weaknesses, and generates a prescription of correction and further development."

Patridge and Mast (1978) state that "preclinical and clinical evaluation play four essential roles in dental education - providing a basis for feedback to students, providing information to faculty about the success of their teaching, certifying student competence, and assuring the quality of health care provided to patients in dental school clinics."
Forehand, Vann and Shugars, (1982) suggest that one of the results of the evaluation in a self-evaluation preclinical study was to indicate, "those aspects of psychomotor skill development that need to be emphasized." This assisted staff with evaluating the program. Vann, May and Shugars, (1981) further indicate that the feedback purpose of evaluation has an evaluative role - referring to feedback, "that tells the learner whether a response is good or bad, right or wrong and why. There is also an informational role to feedback, "that tells a learner whether a response is good or bad, right or wrong, and why, and also what can be done to correct the error." The authors point out that researchers have been interested in quality of product, acquisition time and performance time.

In summary the main purpose served by preclinical evaluation are:

1. To measure terminal competency.
2. To provide learner feedback.
3. To provide information about the instructional program.

The Literature Related to Identifying the Sub-Skills in Psychomotor Tooth Preparation

Preclinical psychomotor tooth preparation skill is evident, according to Salvendy et al. (1973), "only when a task is performed to the experience skilled dentist's quality within the experienced dentist's performance time." The quality may be equated to controlled fine motor
performance.

Montague (1965) states that, "a skilled performance utilizing some kind of equipment to accomplish a particular function is called a man-machine system."

Smith (1972) proposes that the motor components of manually controlled machines are: postural control, transport action, articulated movement, reactive feedback, instrumental feedback and operational feedback. The reactive, instrumental and operational feedback are dependent on eye-hand coordination as well as finger dexterity (Figure 7). Krus et al. (1981) defined the following motor proficiency in children:

Gross Motor Ability

1. Gross Motor Speed - the ability to maintain a high speed during a brief shuttle run.
2. Static Balance - the ability to maintain body equilibrium while stationary.
3. Performance Balance - the ability to maintain body equilibrium while moving.
4. Coordinate Movements - the ability to coordinate the hand and feet in simultaneous or sequential movement patterns.
5. Strength - the ability to perform tasks requiring the use of certain arm, leg, and abdominal muscles.

Gross and Fine Motor Abilities

6. Visual-motor Coordination - the ability to coordinate visual tracking with both gross and fine movements of the arms, hands, and fingers.
7. Response Speed - the speed with which a hand stops a moving visual stimulus.
8. Visual-motor Control - the eye-hand coordination required to perform a number of paper-and-pencil tasks.
9. Upper-limb Speed and Precision - the ability
Figure 7
Component of Manually Controlled Machine
to move the arms and hands quickly with manipulative dexterity and precision.

Items were developed within each of these broad areas.

The purpose of this study was to investigate the structure of motor proficiency among children between the ages of 4 1/2 to 14 1/2 yr. The study was conducted as one aspect of the standardization of a motor proficiency scale, the Bruininks-Oseretsky Test of Motor Proficiency.

From this ordering of proficiencies those applicable to a dental manual skill would be the following:
- Static Balance
- Coordinate Movements
- Visual-Motor Coordination
- Response Speed
- Visual Motor Control
- Upper Limb Speed and Precision

Static balance is a required postural frame of reference for a dentist. Coordinated movements are required when the operator uses the foot to operate a switching mechanism at the same time that the hand performs controlled movements with an instrument.

Visual motor coordination occurs constantly in the use of the eye to monitor hand movements and to receive feedback. Response speed is operational to terminate a cutting stroke accurately. Finally, visual-motor control is a characteristic displayed in the ability to perform very discrete movements of the hand within extremely small limits.
A very marked distinction should be made between "ability" and "skill" (Fleishman, 1972). Abilities are inherent, given characteristics of an individual whereas skill is the development of complex movement patterns or performance. Considerable research has identified eleven psychomotor ability factors. They are as follows:

Control Precision - this ability is characterized by fine highly controlled but not overcontrolled muscle adjustments in large muscle groups.

Multi-limb Coordination - this is the ability to coordinate the movements of a number of limbs at the same time.

Response Orientation - this ability is related to rapid directional discrimination and orientation of movement patterns.

Reaction Time - this is a measure of a person's ability to respond to a stimulus quickly.

Speed of Arm Movement - this is the ability to make a gross movement of the arm without the need of precise accuracy.

Rate Control - this is the ability to anticipate motor adjustments relative to changes in speed and direction of a continuously moving target.

Manual Dexterity - this is the ability displayed where a person executes skillful well-directed arm hand movements in speedy manipulations of fairly large objects.

Finger Dexterity - this ability demonstrates deft manipulation of tiny objects with the fingers.

Arm-Hand Steadiness - this ability is related to precise positioning of the arm and hand without regard to speed or strength.

Aiming - is the ability which is characterized by an eye-hand coordinated movement which precisely directs an extension of the hand to the target.
Wrist-finger speed - is the ability to quickly move the wrists and fingers in a coordination motion such as wide spread tapping.

The abilities suggest by Fleishman which would have the most relevance in the dental man-machine system would be:
- Control precision
- Multi-limb coordination
- Reaction time
- Finger dexterity
- Arm hand steadiness
- Aiming

Harrow (1972) in her taxonomy of psychomotor skills offers the ordering of psychomotor factors presented in Appendix III. Many of these factors would appear to have limited application to the dentist-machine system. However some of those which would appear to have most relevance are:

1.33 Postural Reflexes
2.31 Prehension
2.32 Dexterity
3.11 Body Awareness
3.12 Body Image
3.13 Body Relationships to Surrounding Objects in Space
3.21 Visual Acuity
3.22 Visual Tracking
3.23 Visual Memory
3.24 Figure-Ground Differentiation
3.25 Perceptual Consistency
3.30 Auditory Discrimination
3.40 Tactile Discrimination
3.51 Eye-Hand Coordination
4.43 Reaction-Response Time
4.44 Dexterity
5.34 Highly Skilled Movement Complex Adaptive

Stubbs (1976) in a study of eye-hand coordination suggests that the motor precision of humans is to a large degree the result of, "the advanced human nervous system which guides the hand with such precision." To follow the flow of information through the nervous system he presents the relationships depicted in Figure 8. The author describes his six experiments which consisted of a pointer marking a target under various conditions such as: (a) with or without vision, (b) standing on both legs, (c) standing on one leg, (d) sitting, (e) accuracy-speed, and (f) no accuracy-speed. His conclusion indicated that it was more important to visualize the target rather than the pointer hand; movements taking less than 500 m sec (balistic) are not connected by visual feedback; sitting posture provides a more accurate and more rapid performance and that for movement subject to normal feedback, accuracy and speed (pacing) are traded. These studies emphasize the relationship between speed and accuracy of performance as related to postural and visual stimuli.

Thomas, Mitchell and Solomon, (1979) reported a study of knowledge of result on a motor performance related to the
Figure 8
Stubbs Hierarchy of Information Relationship
age of children. The results suggested, "that while KR was better than no KR during learning, the level of KR preciseness was of minor importance. However, the preciseness of KR during acquisition was of considerable value after KR was withdrawn (retention phase)."

Vann et al. (1981) also reported that a group of students who were provided a preclinical course which was highly guided and relied on detailed checklists and exhaustive faculty feedback resulted in a significant increase in product quality compared to a control group.

Weinstein, Kiyak, Milgrom, Ratener and Morrison, (1979) studied the relationship between the results of an O'Connor's Tweezer Dexterity test and the quality of care among dental practitioners. Their conclusions were that,

... the findings of the present study indicate that a test such as the O'Connor Tweezer Dexterity test may prove to be a useful component of a selection device to select dental students, as well as to evaluate the performance of dental practice. This test is primarily a test of speed and manual dexterity.

Suddick, Yancey, Devine and Wilson, (1982) describe the construct of field dependence-independence (FDI). They conclude that individuals who possess the perceptual-cognitive construct of field independence are able to rapidly discern and identify constituent parts of complex visual fields. They appear to perform better in clinical instruction.
Fleishman, (1972) states that, "many students have difficulties in dental school because of poor manual dexterity or spatial visualization." An examination of representative dental texts and manuals provides a sample of the type of instruction provided for tooth preparation procedures. Bell and Grainger, (1971) give the following operational instructions in the use of a rotary cutting bur:

The general depth of the pulpal wall is just pulpal to the dento-enamel junction - Holding the shaft of the bur parallel to the long axis of the crown of the tooth commence to removal all non-coalesced pits and fissures.

Hand grasp of instruments are provided in diagrams.

Charbonneau, Cartwright, Comstock, Kahler, Synder, Dennison, Margeson, (1981) after cautioning that the instrument rotates at 300,000 - 500,000 r.p.m. state that, "a carbide bur moves through tooth tissue with only a lightly directed force of from 2-4 ounces. The technique has been likened to that of using an air brush." "The bur action motion conservatively reducing thin layer after thin layer."

Obviously from these two examples a considerable aspect of skill acquisition is approached through the method of discovery.

Project Accorde (1975) is a teaching method designed for self-instructional use. The student syllabus provides instruction in psychomotor skills as follows:
Practice entering the tooth at ultra speed with the air/water and withdrawing the bur in the same manner as on the plastic tooth. Notice how enamel and dentin respond differently. How do you know when you reach dentin? How do you know if you can reach the pulp?

To summarize this section devoted to identifying sub-skills and factors which effect sub-skills, it is noted that time of performance is an important consideration. A task is considered skillfully performed not only if the quality of product meets a standard of excellence but also if the performance is completed within a prescribed time limit.

As part of the man-machine system a dentist performing a manual task exhibits the following sub-skills when preparing a tooth:

1. The skill of maintaining proper posture.
2. The skill of maintaining hand steadiness.
3. The skill of identifying appropriate feedback cues.
4. The skill of responding to the cues received in a proper manner and at the correct time.
5. The skill of maintaining a proper hand grasp on an instrument.
6. The skill of guiding an instrument through precise finger movement or through the exertion of precise finger pressure.
7. The skill of moving a foot at the same time that the hand is performing a controlled movement.
8. The skill of visually tracking over very precise circumscribed distances, accurately.

9. The skill of identifying spatial relations in very fine dimensions.

The Literature Related to the Setting of Behavioral Objectives for Learners

Objectives for Learners. Setting objectives of observable performance for students has been accepted in teaching for some time. Recognizing that objectives should be specified has not necessarily meant that this preliminary requirement to instruction has been generally adopted. This is especially true in professional schools where the instructors may be expert practitioners in their own techniques but are not necessarily as well-informed in sound teaching methodology.

Prentice and Metcalf (1974) in outlining a teaching workshop for medical educators stated that, "Although the Ph.D. and/or M.D. is a fairly reliable index of scientific competence, the degree alone does not ensure an ability to teach."

If objectives are to be operational they should be phrased in behavioral terms according to Mager (1962).

Another source (United States Department of Health, Education and Welfare, 1972), points out that objectives have three parts:
(A) **Stimulus** - a situation or condition that causes the student to take some action.

(B) **Response** . . . the action taken by the student when he is given the stimulus.

(C) **Condition** . . . under which the student takes the action - such as time limits, special instruments, etc. (Given 5 minutes, using a periodontal probe, the student will - etc.)

Muhich (1976) reports about the use of criterion-referenced measurement in the initial acquisition of typing skills. She points out that there is a higher validity in measurement when test items clearly focus on instructional objectives. This is a very desirable outcome.

Another advantage of using explicitly stated objectives is that students develop the ability to self-evaluate (Gale, Koran, Grainger and Watson, 1976). Objectives clearly outlining required student behavior in combination with detailed criteria of performance communicate to the student not only, what is to be learned but also, how learning can be facilitated.

**The Literature Related to Identifying What Should be Evaluated**

Gronlund (1966) offers some general principles on designing an evaluation model as follows:

1. Determining and clarifying what is to be evaluated always has priority in the evaluation process.
2. Evaluation techniques should be selected in terms of the purpose to be served.
3. Comprehensive evaluation requires a variety of evaluation techniques.
4. Proper use of evaluation techniques requires an awareness of their limitations as well as their strengths.

5. Evaluation is a means to an end and not an end in itself.

With these guidelines we can now examine what should be examined in preclinical evaluation. There usually are three methods available: one is to evaluate product of performance, another is to evaluate process and thirdly to evaluate product and process.

**Literature Related to Evaluation of Product of Performance.** One of the studies quoted often in clinical evaluation is by Houpt and Kress (1973) titled "Accuracy of Measurement of Clinical Performance in Dentistry". This study examines the reliability and accuracy of rating end products of operative dentistry. The research design used instructors, dental students and dental assistants as evaluators of cavity preparation, cavity liner and restorations. These were prepared in extracted teeth.

The authors concluded that there was little evidence of validity of current methods in dentistry (even though only reliability was being studied). They stated that overall, performance evaluation was reliably judged. Less experienced personnel (dental assistants) had lower consistency of evaluation although after training the dental assistants were the only ones to markedly improve. A two point scale appeared to provide a basis for judging more consistently than a three or five point rating scale.
Several aspects of this study are disturbing. Although the title of this article is "Accuracy of Measurement of Clinical Performance in Dentistry" the articles does not describe clinical performance at all. The article's title would be more suitable if stated as Relating the Reliability of Evaluators on Operative Procedures in Extracted Teeth. Even if the title stated that it was, "a study of evaluator reliability of preclinical operative technique," it would be more to the point. Definitely the study could not be construed as measuring clinical performance. The design is rather complicated and if the researchers used extracted teeth for all their specimen series (they did not state that they duplicated any of the series through impressions), a high degree of inconsistency could be expected. In evaluating operative procedures 0.1 mm is a significant measure and it would be impossible to arrange extracted teeth to replicate three parallel tests to this degree of accuracy. Natural teeth themselves present such a variation in anatomy that one would expect specific criteria to provide variations of opinion.

The analyses of agreement by using Pearson's product moment may also introduce errors due to chance. Fleiss (1975) states that:

It should be obvious that no index of agreement is informative by itself, that it should be expressed as a relative excess (or deficit) over the degree of agreement expected by chance alone.
He offers as the most defensible chance-corrected intra-class correlation coefficients either Cohen's $k$ or Maxwell and Pelliner's $r$.

Hinkleman and Long (1973), studied inter-rater and intra-rater reliability in a preclinical end product. They found that recent graduates had as much or more agreement as did instructors who had been in practice seven years. The researchers do not tell us how long these evaluators were experienced in evaluation.

They also conclude that the pass/fail, two point system was slightly more reliable although this type of rating scale should have a 90-100% agreement level and suggest that criteria used in assessment as well as in teaching may contribute to inconsistency stating, "Perhaps the criteria may only exist in theory."

This study did not appear to correct its data for the possibility of chance agreement. The authors indicate that the problem may be more with the evaluator than with the evaluating system.

Another report which examined within examiner and between examiner consistency was presented by Lilley, ten Bruggen Cate, Holloway, Holt and Start (1968). This researcher and his co-workers had three evaluators examine dental operations on plastic teeth. The conclusions drawn were that intra-examiner variability was better than the inter-examiner variability. They also found that the reliability of grading decreased with the complexity of the
technical procedure under study. A conference to "attempt to lay down criteria" had little effect in improving the reliability.

This study may suffer from a few deficiencies in design. To use only three examiners is to study a very small population. As the researchers reported, one of the examiners was lenient and displayed intra-rater inconsistency. There appeared to be no independent assessments as evidenced by the statement,

It was interesting to note that one examiner appeared dominant and remained stable in his marking while the other two attempted to compromise with him.

The fact that a training session (conference) failed to improve the reliability also makes one suspicious of the type of training session provided, the criteria describing the scoring or possibly the co-operation of the evaluators. No correction for chance agreement appears to have been administered.

A report by Schiff, Salvendy, Root, Ferguson and Cunningham (1975), describes an objective method of evaluating qualities and cavity preparation such as pulpal floor depth, smoothness and flatness. These objective measurements were obtained by using an instrument similar to a profilometer. The authors labelled the instrument a pulpal floor measuring instrument. Although the instrument provided students with more consistent evaluations, routine
use of such an instrument is impractical. It may also be undesirable for instruction. Possibly there may be some application in the early stages of preclinical techniques for this device, however, it could delay the development of judgment by vision.

Two other studies which use devices for generating feedback are described by Salvendy, Joost, Ferguson, Cunningham, Schiff, Wilko, (1976); and Salvendy, Root, Schiff, Cunningham, Ferguson (1975). The devices described measure forces applied during instrumentation and were shown to reduce training time by two-thirds. These devices have limited application in evaluation but do illustrate that devices can be employed for providing consistency in instruction.

Dilley et al. (1978), reports the results of self-paced instruction for acquisition of psychomotor skills. The authors of this paper found the students using self-paced instruction acquired their skills quicker. Some of this effect the authors attribute to consistency of instruction. To assess quality of the products this study established rater reliability by having a second rater independently evaluate each procedure and the consistency between rater was confirmed with Pearson's product moment correlation coefficient. No correction for chance agreement appears to have been used.

Salvendy, Joost, Cunningham, Ferguson, Wilko and Dees (1976), also studied examiner agreement (or lack of) on
plastic tooth preparations. Some conclusions that this study comes to is that the low agreement within and between evaluators would appear to result from a lack of well defined criteria of what constitutes an unacceptable, acceptable or excellent restoration. The data submitted to regression analysis also indicated that 56% of the variance of overall quality was due to the assessment of anatomic form.

Shugars et al. (1981) describes a system of evaluation in a preclinical technique course. The course was organized to meet the following objectives:

- to provide comprehensive and valid assessment of student
- to establish competencies and readiness to enter the clinic, and
- to provide systematic feedback on student progress and performance.

The method employed was to assess cognitive skills using written mid-term, final and periodic quizzes. Psychomotor skills were assessed from two aspects: 1) process grades were assigned from daily project grades and clinical judgment examinations; and 2) product assessment was obtained from practical grades. After one year, the students expressed their satisfaction as evidenced by their response that the overall grading and evaluation process was clearly stated, fair, appropriate and valid.
Although the report of this system of evaluation does not provide details it would be interesting to know what constituted the day to day assessment. If the evaluation was based on the completed product it would not truly be a process evaluation. This concept of assessing process and product appears to have merit in evaluating psychomotor skills, however, often there is a misunderstanding as to what is process and what is product.

A tooth preparation exhibits cavity features such as those illustrated in Figure 9. These features are the elements which are evaluated to assess product. Since the cavity wall dimensions, extensions and relationships are very specific for success or failure, the evaluator is assessing a multi-factorial product. This may be one of the reasons for the low reliability associated with evaluating product in tooth preparation skills.

Lividatis, Mastrola, Bradbury, Maddox and Dopson (1976) evolved a model for clinical examinations. It is interesting to review their checklist which demonstrates a major emphasis on evaluating end product (Appendix V). They also identified an aspect peculiar to tooth preparation evaluation which they labelled critical factors, stating:

A few factors considered critical to the total clinical procedure, were termed "critical factors," and failure in any one of these resulted in failure of the entire examination. An example of a critical factor is the removal of caries.
Figure 9. Cavity features exhibited in tooth preparation.

(Classification - intracoronal class II for amalgam.)
These critical factors are similar to those features identified in the National Dental Examining Board of Canada checklist as an automatic failure (Appendix VI).

In summary, it can be stated that product of performance has been used extensively for evaluating tooth preparation skills. It is important to evaluate product for quality, in order that a standard will be emphasized; nevertheless, the sub-skills of tooth preparation are not addressed. Product evaluation does not take into account how the learner arrived at his goal. As a result there can be very limited evaluative or informational feedback. The learner cannot benefit from this type of measure.

If product evaluation is used as summative evaluation for promotion then it is essential that the problems of reliability are recognized and minimized. Product evaluation requires explicit criteria as well as experienced evaluators. These experienced evaluators should receive sufficient calibration so that inter-rater reliability is high.

These studies related to evaluation of product also support the premise that the fewer intervals on the rating scale the more reliable the evaluator's grading will be.

There is an aspect peculiar to the evaluation of tooth preparation product which may be termed critical factor. Failure in the critical factor contributes to a failure of the entire product regardless of how well any other aspect of the preparation is assessed.
The Literature Related to Process Evaluation. Whereas studies which examine product are numerous, there are few sources in the dental literature which describe process. Occasionally a report states that process was being evaluated when in effect the criteria described relate to product of performance. Statements such as student performance, or student performance criteria must be examined critically to determine whether the authors are referring to product of performance or process of performance.

A study of considerable relevance to process evaluation is provided by Mescher, Rossman, Biller and Hunter (1978). They point out that the objectives of using a process evaluation instrument are to:

1. develop a more definitive method of introducing basic instrumentation principles to beginning dental hygiene students by providing specific performance criteria;  
2. provide students with guidelines for self-evaluation of clinical skills;  
3. provide students with diagnostic feedback appropriate to their clinical performance levels;  
4. establish standards for student clinical performance;  
5. develop a standard format for faculty to identify and record specific student behaviors;  
6. provide a quantitative measurement of process performance; and  
7. improve intrafaculty and interfaculty reliability in the evaluation of student performance.

A representative portion of their checklist is provided in Appendix VII. Each skill is further clarified
in the text. For example, the item - "on same arch" is explained as:

The Iowa faculty prefer same-arch fulcrum to facilitate control and leverage. Advanced students may be introduced to cross-arch fulcrums when necessary.

Process behavior, from the psychologist's point of view (Merrill, 1972) is:

. . . dependent on the basic learning processes of discrimination, generalization and chaining. Instruction is the process of manipulating the environment in order to facilitate and combine the learning processes so that the intended psychomotor behavior outcome is produced.

Mackenzie (1973), suggests that "the product approach should be supplemented by other forms of evaluation". In this way, the instructor would have more information on the student's clinical proficiency to make instructional decisions.

Shugars et al. (1981) used a process grade which was not based on the end product. The project was assigned a grade according to the instructor's assessment of student management and understanding of the task.

One source, United States Department of Health, Education and Welfare (1972) cautions about making a distinction between process and product and that evaluation of interim product is only a rough approximation of process evaluation.
Gold (1978) describes process as one of seven phases of task analysis and says that process is the way in which the task is taught. He subdivides process into three sections titled: "format, feedback and procedure."

According to this author, format refers to the presentation of the content which, for example, could be match to sample for a single piece of learning or to backward chaining in multiple-piece learning. Feedback refers to the learner receiving information which tells him/her what is required and whether he/she is achieving the desired goal. Procedure refers to a description of the proposed training plan. This author applied this task analysis to train adult individuals moderately, severely, and profoundly retarded, blind and deaf blind. He states that the training procedures were modified throughout the study.

In summary, it is evident from the literature that process evaluation has a significance in dental clinical and preclinical evaluation. This evaluation consists of complex observations and requires a type of checklist instrument to record the various selected behaviors. Process evaluation is subject to program or environmental variations to a large degree. Examination of interim product only provides a rough approximation of process. Process format may vary as well the evaluation.
The Literature Related to Specifying Criteria for Product or Process

Levine (1978), in his section title referencing states, "the advantage of criterion referencing is that the data on the examination can be directly related to real-life performance." He continues by explaining the disadvantages which include the fact that the criterion standards are sometimes difficult to derive and that qualified observers may disagree on whether a particular performance is satisfactory.

Charbonneau et al. (1981) suggest that,

For learning to best occur, well-defined operational criteria can be used by the faculty and students alike to identify in mutually understood terms the qualitative degree to which treatment performance has occurred.

The acceptability of a dental procedure such as tooth preparation has been based on criteria as simple as "will it fly" (Jordan, 1980) to the extensive descriptions in Appendix VIII. To the experienced operator, criteria are a second sense which require minimal definition. To the uninitiated, criteria are the only guided means to achieve the desired result.

Salvendy, Hinton, Ferguson and Cunningham (1973), concluded that:

... quantitative and qualitative criteria must be established for judging, teaching and learning technical procedures, in this case the Class I occlusal cavity preparation.
Quality criteria to evaluate tooth preparations have been established for teaching and practice (Appendix VIII and IX). If there is any fault with these standards it is that students and instructors are intimidated by their comprehensiveness. Nevertheless, there is sufficient evidence in the literature to indicate that criterion-referenced evaluation has an advantage over traditional evaluation which does not provide a systematic standard of features.

Dhuru, Rypel and Johnston (1978), concluded that experienced instructors were better evaluators than "new" instructors who were recent graduates. Regardless of experience, criterion-referencing exhibited an increase in correlation coefficient. Although it is not clear from the background of the instructors as to whether or not they themselves were trained by criterion-referencing, one cannot help but speculate about the potential consistency of evaluation done by evaluators originally trained according to the same criterion.

The Literature Related to Evaluative Methodology

Singer (1972) states that in the acquisition of a psychomotor skill there are three factors: that which is to be learned; the learner and the learning environment.

That which is to be learned should be specified with explicit objectives (Mager, 1962; Muhich, 1976) and standardized criteria (Charbonneau et al., 1981).
According to Singer (1972) the learner exhibits many variables related to genetics, early childhood perceptions, abilities, sense activity, perceptions, attitude, motivation, level of aspiration, personality, age, body build, physical measures, sex, intelligence and fear. As a result of these many variables students, exposed to the same instructional material, will exhibit varying performance. One can only speculate why more structured individualized instruction or remedial instruction is not built into programs.

The final area of concern - the learning environment is the area which can be manipulated the most.

What is the best format for psychomotor teaching and evaluation - the guided method of Ausabel (1963) and Skinner (1968) or the discovery method of Dewey (1969) and Bruner (1973)? Singer (1977) feels that psychomotor instruction should be taught according to the desired outcomes. He suggests the following approach:

1. If the purpose of learning a skill is only for the highest level of performance in that skill, then a guided and prompted method of learning would seem to be the appropriate choice, especially if there is concern for economy in training time.

2. If the purpose of the learning situation is to lead to the application of what has been learned for transfer to other related skills and situations, it would seem that some form of discovery, problem-solving, or trial-and-error strategy should be employed.

3. Self-paced, closed-loop tasks should be learned primarily through a guided technique, for response consistency.
4. Externally paced, open-loop tasks should be learned primarily through a discovery technique for familiarity with diverse situations and response adaptations.

5. The later learning situation should be considered and might determine what the prior learning method should be; e.g., if subsequent experiences are going to occur with the availability of prompts and guides, then it would seem to be a waste of time and effort to conduct the initial learning experience under a discovery method.

Vann et al. (1981) found that the quality of product improved in a study which compared a Highly Guided Method with Informational Feedback (HGM-IF) to a traditional approach.

Should product or process or some combination of the two factors be evaluated? The literature is not clear on this question. One can only follow the suggestion that recommends basing evaluation on a broad comprehensive basis (Gronlund, 1966; Mackenzie, 1973). According to these educators, the more elements evaluated the better will be the evaluation.

The scoring should be on a limited rating scale for maximum reliability and validity (Houpt and Kress, 1973). Evaluator consistency should be highest when performance is defined on a rating scale of from three to five (Snyder and Ryge, 1973).

If the major purpose of evaluation is to substantiate promotion decisions, to provide feedback to the students and to provide information about the effectiveness of the instructional program (Patridge and Mast, 1978; Lutz and
Mast, 1975) then the process and product records should be
designed to provide this information.

Finally, the demands on the instructor should be
considered and whatever grading or reporting is required the
record-keeping and observations should be kept informative,
consistent and simple (Hord, 1979).

The Literature Related to Characteristics of
Instructor Evaluators

Koeningburg (1975) suggests that the role of a
clinical or preclinical instructor is that of observer,
judge, teacher, colleague, assistant as well as role model.
In explaining the role of judge he states,

When we recognize the differences of opinion, and
there are valid differences, we must be prepared
to expect no greater precision from our students
than we ourselves can assign to the same set of
standards.

Mescher and Kerber (1982) noted that inter-instructor
variance not only exists but that the variance is of such a
magnitude that it does affect student grades. They suggest
that raw scores should be converted to standard scores for
rank-ordering to reduce the effect of variance.

Wigton (1980) designed a methodology for a study which
required two separate evaluators to view medical clinical
performance by students. He found that there was a bias on
the part of instructors toward personal characteristics of
the students. He suggests that the standard of performance
should be defined more precisely.

Holder, Drasgow and Pierce (1976) found that the "good guy" evaluator usually obtained better performance on objective tasks. The "good guy" factors were identified as being friendly, likable and helpful. Other descriptors for the facilitating factors were empathy, respect, genuineness and concreteness.

Mackenzie et al. (1979) interviewed students in regard to instructor actions and the resultant student behavior. He found that rewards of any nature whether they were positive grade, praise or a compliment by the instructor resulted in positive student behavior. On the other hand punishing statements or actions as well as inconsistencies would result in future avoidance behavior. At times students would describe inconsistencies as punishing which would result in frustration, boredom and extinction. The author described extinction as a contingency when nothing of significance happens. When a behavior results in extinction the behavior decreases in probability.

Most of the other literature which was examined from secondary sources (Emling and Fritz, 1978; Cotsonas and Kaiser, 1963; Jacobson, 1965; Jacobson, 1966; Carkhuff, 1969; Mayberry, 1973; Stritter and Grimes, 1975) indicated that students were not concerned about their clinical instructors' evaluating skills. These studies listed characteristics desirable in teachers such as: enthusiasm, organization, good communication skills, knowledgeable,
availability, rapport and fairness. It is possible that the instruments used to collect these data were not sufficiently open-ended to allow the students to express their genuine feelings.

To summarize this section it is significant to note that instructors have several other roles besides that of an evaluator. They serve as colleagues, role models, assistants and supervisors. Instructors have biases and their evaluations have variance which can affect student grades. Student performance appears to improve for instructors who are likable and helpful. Survey instruments in most cases do not disclose student concerns about instructor evaluative skills.

Final Synthesis of the Review of Literature

Purpose

The evaluation of clinical and preclinical performance can be categorized according to the purpose served under the heading summative evaluation and formative evaluation. Summative evaluation serves to provide information to a licensing body or a school department regarding the certification or promotion of the learner. Formative evaluation provides feedback to the learner during his/her skill acquisition stage. This information can guide the student by letting him/her know whether he/she is attaining the objectives of the course of instruction and why he/she is attaining or not attaining his/her objectives. He/she
should also be informed by the feedback as to what he/she can do to improve his/her performance.

The formative evaluation is also useful to analyse the effectiveness of the course of study.

Sub-Skills

The sub-skills of psychomotor tooth preparation consist of those actions which a learner is required to perform in order that he/she is able to complete the procedure. He/she is considered a component of a man-machine system in which the operation of the system heavily depends on the operator's posture, perception, perceptual motor integration and coordinated movements. Certain psychomotor abilities are applicable to this man-machine system such as:

- control precision
- multi limb coordination
- reaction time
- finger dexterity
- arm-hand steadiness
- aiming

Abilities are natural aptitudes.

Seventeen psychomotor factors of those in Appendix III were identified as applicable to man-machine system represented in the dental operator.

Speed of operation is a factor which has to be considered in enunciating levels of sub-skill development.
Manual dexterity is an important sub-skill of psychomotor tooth preparation skill as well as spatial visualization. Other necessary sub-skills are:

- maintaining hand-steadiness
- identifying appropriate feedback areas
- responding to the cues in a proper manner and at the correct time
- maintaining a proper hand grasp on an instrument
- guiding an instrument through precise finger movements or through the exertion of precise finger pressure
- moving a foot at the same time that the hand is performing a controlled movement
- visually tracking over very precise circumscribed distances accurately
- identifying spatial relations in very fine dimensions

**Setting Behavioral Objectives**

Evaluation as well as instruction is most effective if behavioral objectives very explicitly specify what the learner's behavior should be. The properly designed objective states in behavioral terms (1) a stimulus, (2) a response, and (3) a condition.

**What Should Be Evaluated?**

The best evaluation is obtained by evaluating both product of performance as well as process of performance. Product of performance although necessary for the evaluation of end product does not gauge the learner's skill acquisition. Problems of product evaluator consistency
exist because evaluators have varied backgrounds and are assessing a multi-factorial entity. Certain product features are critical and contribute to failure regardless of how well other features are executed. Finally, product evaluation is more accurate if the rating scale is kept to fewer intervals.

Product evaluation can easily be confused as process evaluation. Process evaluation adds a needed dimension to overall student performance evaluation and also provides very prescriptive student feedback. Process instruction may be formulated as "match to sample" or "backward chaining."

**Criteria for Product or Process**

Criteria, very definitely stated, assist in establishing standards to which a learner as well as his instructor can consistently refer. Although there are significant outcomes from the use of criteria in referencing evaluation there are problems in obtaining agreement amongst some authorities as to what a criterion should consist of. Some criteria are so complex that they are not practical as a means of communicating quality of excellence, acceptability or failure.

**Evaluative Methodology**

Psychomotor skill acquisition consists of three elements - the learner, that which is to be learned and the learning environment. In the application there are several methodologies, guided-informational feedback and a discovery methodology. Some authors suggest that the highest level of
performance is attained through a guided methodology, especially if there is concern for economy of training time.

**Instructor-Evaluator Characteristics**

Preclinical instructors acquire the role of observer, judge, teacher, colleague, assistant as well as role model at different times. Instructor consistency should be reconciled with the student's perception of standards. Some instructor variance affects student grades. Instructors can have personal biases towards individual student characteristics. Students appear to perform better for likable and helpful instructors. Through their actions instructors can significantly reinforce, punish or extinguish student performance. Students appear to place notable importance on instructor enthusiasm, organization, knowledge and communication. Concern about instructor skills as an evaluator have not surfaced.
CHAPTER III

A PROPOSED MODEL FOR THE EVALUATION OF PRECLINICAL PSYCHOMOTOR SKILLS

Introductory Statement

There is sufficient evidence to indicate that there are valid alternatives to the traditional methods of evaluating preclinical psychomotor skills in tooth preparation.

The traditional learning strategy was primarily discovery learning; it would appear that the guided method has merit (Singer, 1972; Vann et al., 1981). Dental psychomotor skills are associated with a need for high product quality. Singer (1972) proposed that maximum quality is attained through a highly guided learning strategy. This entails a very structured feedback mechanism. Vann et al. (1981) demonstrated this phenomenon in his study.

Traditional emphasis in evaluation was on product of performance almost exclusively. There is evidence (Mescher and Kerber, 1981) that process has an important role in the evaluation procedure. Process of performance evaluation assists the learner with prescriptive feedback as to how he/she should execute procedures. As a result the assessment of both product and process indicates a more comprehensive evaluation is possible (Shugars et al., 1981).

Traditionally objectives were not explicit nor phrased
in behavioral terms. Many learning activities were unclear to students. With the advent of behavioral objectives students know precisely what outcomes are expected of them (Mager, 1962).

Standards of products and processes traditionally were specified in general terms. This allowed a wide range of interpretations as to what was acceptable or unacceptable. Standards of product have now been very precisely defined with criteria and this has improved the reliability of evaluator assessments (Salvendy et al., 1976). Process criteria, although of equal importance, do not appear to have received as much attention in the research (Mescher and Kerber, 1981).

Product of performance when defined with precise criteria improve the reliability of evaluator assessments (Salvendy et al., 1976).

Evaluators have in the past assessed preclinical product or process in terms of their own educational and professional practice experience. This also contributed to instructor inconsistency when marking or evaluating. There is evidence that the calibration and training of instructors in evaluation improves reliability of evaluation (Mackenzie et al., 1982; Houpt and Kress, 1973).

This thesis study was undertaken in order to address the problems stated previously. A model which will minimize the identified problems will be described in this chapter.

The proposed model consists of the major components illustrated in Figure 10. These components offer options
FIGURE 10  THE MAJOR COMPONENTS OF A MODEL FOR EVALUATING PSYCHOMOTOR TOOTH PREPARATION SKILLS.
which, according to the literature, and, if selected properly, will optimize the instruction and hence the evaluation of psychomotor skills. The illustration indicates the selection of a guided strategy of instruction. This favors the development of psychomotor skills and economy of instructional time over a method by discovery. The referencing selected is that of criterion-referencing as opposed to normative referencing. This dependence on criteria assumes explicitly stated objectives. Feedback which is highly structured has been identified as optimizing time of performance. The time of performance as measured during testing situations has been shown to be of significance and should be instituted as a time frame within which a practical test is completed. (See Appendix 10, Sample Practical Test). On the other hand, the time of acquisition (of skill) is not as significant in that different students require different amounts of time to solve problems related to acquiring these skills. Process as well as product should be evaluated during psychomotor skill acquisition in tooth preparation. This will provide better feedback as well as a broader base on which to assess these skills.

**Background**

Preclinical psychomotor skill instruction is usually initiated in the first semester of year one. This instruction is provided in courses which explain and
describe tooth morphology. These courses may variously be titled: "Dental Anatomy", "Tooth Anatomy", or "Occlusion."
The student's psychomotor activities consist of either carving teeth from wax as well as plastic blocks or building the crown of a tooth by using incremental wax additions. These activities are designed to develop a perceptual concept of the sophisticated tooth size, shape, contour and the relationship between various teeth.

With the prerequisite of dental anatomy established, students progress to the second term of first year. At this time, the course in preclinical tooth preparation skills is provided. The preclinical instruction consists of a laboratory exercise which follows a parallel didactic course. In this laboratory course students are introduced to intra-coronal tooth preparations related to several varieties of restorative (filling) materials.

Cavity preparations may be required in plaster teeth which are approximately twice normal size. When the concept of tooth preparation appears to be understood by the student, he/she is allowed to proceed and perform these tooth preparations on natural sized plastic (Ivorine) manikin teeth. Some schools have these exercises as bench-top exercises. Other schools have the teeth mounted in a manikin head which simulates a patient's head.

In an environment such as the one described the student is introduced to the skills of tooth preparation. He/she continues at this level for a period of two
semesters. If at the end of this period he/she demonstrates the skills necessary to perform the tooth preparations for clinic patients, he/she is promoted. It is essential for a student to master these skills in order that safety and a reasonable amount of proficiency may be demonstrated before the clinical encounter. Evaluation of preclinical tooth preparation usually takes the form of product of performance. Quality assessment is a priority. Traditionally, process and quantity are assessed globally by instructor consensus or through anecdotal comments.

Recently changes have been noted in clinical and preclinical evaluation and instruction. Morgan and Irby (1978) identified the following trends in the literature:

There is a Trend to Using Instructional Objectives

With the setting of instructional objectives the units for learning are being characterized through task analysis into criteria. During the performance of a skill it has been shown that process is measured optimally by criteria referenced measurement. When a criterion specifies a level of performance it becomes a standard of that performance, often termed a competency. As a result, many of the essential competencies are being established at a mastery level.

The Current Trend Focuses on Student Learning to a Greater Extent

With faculty expectations more explicitly stated by using criteria students have a better understanding of what
they should be learning. There is better communication between staff and students. Although many behaviors can be graded there is a recognition of need for practice time without grading. Some systems of clinical evaluation employ separate staff for instruction and separate staff for evaluation.

The Clinical Evaluation Process is Used for Improving Instruction

The explicit expectations in criteria have become functional definitions of the objectives. This provides the student with a sense of emphasis, assisting him in keeping his performance directed toward the desired objectives. For example, if the criteria specifies the use of time as an important objective, the student will become aware of time management.

There is a Trend to Involve Students to a Greater Extent in the Process of Evaluation

In providing students an opportunity to carry out evaluation in a clinical/preclinical course the dental schools effectively;

- provide them with an understanding of the system of evaluation
- encourage the students to become involved in self assessment
- introduce the students to peer evaluations - since all the aforementioned are desirable qualities
this tendency should be employed by more schools in the future.

There is a Trend to Recognize the Problems Associated with the Evaluator

Many studies have indicated that clinical evaluation has very poor intra-observer and inter-observer agreement (Irby, 1978). Various training sessions have been proposed in an attempt to provide part-time staff, who act as evaluators, with a better consensus of opinion on criteria and standards. This process is termed calibration of observers and is suggested immediately before clinical or preclinical marking sessions.

There is a Trend Toward Using Simulation Techniques

Dentistry has for a very long period used manikins which provide simulation of patients' oral and dental anatomy under clinical conditions. However, some students will take the easier way out and not perform the procedure in a manner which simulates the operation as if it is being performed on a patient. Incorrect positions are used which may facilitate completing the dental operation but would never be available in the clinical setting. The human dentition is accessible only through the space limited by the comfortable opening of the jaws. Operations on the molar teeth are often only possible with indirect vision through a mirror.
There is a Trend to Using Patient Records as a Means of Clinical Assessment

This may be useful for a discipline such as oral diagnosis or radiology but provides limited application in the assessment of psychomotor skill. Possibly there would be some use of evaluating manual skills from an assessment of the time spent on various operations (Eisner, 1981).

There is a Trend to Consider the Appropriateness of the Assessment Scale and the Assignment of a Score

Some studies indicate that evaluations are more reliable if a two category pass/fail system is used (Houpt and Kress, 1973). There is also less student anxiety about their standing when they are identified as either displaying a satisfactory or unsatisfactory performance. This lack of competition for standing, however, does not recognize students who are superior and there is little incentive to excel.

A two category scale provides limited information for student feedback. Students gain more insight from at least two categories of satisfactory level as well as two categories of unsatisfactory level.

In addition to these trends there is still the quandary: how should the various attributes be assessed? Barrows et al. (1978) expresses his concern that, "separate valid assessment of the various components of the encounter be provided."
For this model, the assumption is made that where cognitive and psychomotor skills interface there should be separate valid assessments of these two domains. In tooth preparation there is a cognitive conceptual skill embodied in spatially visualizing the features of a tooth cavity preparation. There is also the psychomotor skill which the student develops, that permits the hands to achieve what the brain and senses visualize.

Description of the Model

Psychomotor skills acquisition may be represented as depicted in Figure 11. The initial cognitive phase requires considerable knowledge for the student to execute his/her task. This is followed by an associative phase which consists primarily of practice with the learner identifying meaningful cues as feedback. Initial feedback is visual and eventually this is surpassed by proprioceptive feedback. Piano players or typists exhibit these two phases very dramatically.

It is important to keep these phases of psychomotor skill acquisition in mind as the model is described. When in use the model should be adapted with flexibility in order that the phases of skill acquisition are addressed. The model therefore is dynamic and the evaluation should be adapted to the characteristics which the learner displays at each stage.
Figure 11

Sequence of Psychomotor Learning Related to Cognitive and Affective Factors
In the early stages therefore, the student should be observed and the behavioral objectives interpreted or prioritized to assess the knowledge and knowledge integration which should be taking place.

In the associative stage the learner should be examined on how well he/she is recognizing and responding to cues which guide his/her performance.

In the automatic stage the learner should be evaluated on how many features of behavior are reaching a state of control practically by reflex action.

This element of evaluation may be exemplified in the individual who is learning to operate an automobile. He/she initially has to use a checklist for seating, securing his/her seat belt and adjusting the mirror, etc. In the intermediate phase these functions are performed from memory but with considerable thought. In the final phase these activities are performed while the operator's attention is on conversation or some other activity.

The Purpose

In this model the evaluation of these preclinical skills was considered to serve the following four purposes.

1. to provide feedback to the student about the quality of his performance and about the rate of his skill acquisition;

2. to provide information about the instructional program;
3. to provide assessment of the student's level of performance for promotion;
4. to assist the student with learning how to self and peer-evaluate.

The first three purposes are conventional and their importance has been explained earlier. The fourth purpose is unique to this model and is based on the assumption that if the student is invited to participate in the evaluative process he/she will: (1) be more knowledgeable about the system of evaluation, criteria, etc.; and (2) be conditioned for future peer review procedures. In order that this purpose will become operational, knowledge about criteria and perceptual discrimination of products will be formulated as an objective.

The Skills
Dental tooth preparation psychomotor skills, for the purpose of developing this model, are categorized as primary or secondary. The primary psychomotor skills are those associated with factors listed in Harrow's Taxonomy and which also contribute directly to the operations on the tooth. These are skills such as:
1. The skill of maintaining proper posture.
2. The skill of maintaining hand-steadiness.
3. The skill of identifying appropriate feedback cues.
4. The skill of responding to the cues received in a proper manner and at the correct time.
5. The skills of maintaining a proper hand grasp on an instrument.
6. The skills of guiding an instrument through precise finger movements or through the exertion of precise finger pressure.
7. The skill of moving a foot at the same time that the hand is performing a controlled movement.
8. The skill of visually tracking over very precise circumscribed distances accurately.
9. The skill of identifying spatial relations in very fine dimensions.

The manner in which these skills were identified was through a task analysis of a dentist's performance during tooth preparation. Those behaviors which matched the factors in Harrow's Taxonomy were categorized as primary skills.

The skills which can be categorized as secondary psychomotor skills of tooth preparation are those behaviors which are in Harrow's taxonomy but are not utilized in working directly on the tooth. These are:

1. The skills of instrument assembly.
2. The skill of adjusting the operatory light.
3. The skill of instrument transfer.
4. The skill of completing an operation within a reasonable time frame.

The Behavioral Objectives

Some of the identified skills will be specified in
this model in behavioral terms according to Mager (1973). For example: the skill of maintaining proper posture would have the following objectives stated:

- The student will demonstrate his/her ability to adjust the operator's stool to the ideal height and position 100% of the time.

- The student will demonstrate his/her ability to operate from the adjusted stool maintaining proper posture 100% of the time.

For the second skill of maintaining hand steadiness the objective would be stated as follows:

- The student will demonstrate his/her ability to execute a cavity preparation which will not be more than 0.5 mm wider than the bur with which the cavity was prepared.

The other skills will similarly be described in behavioral terms. To include all the objectives in this paper serves little purpose to the explanation of the model. For a more complete list of objectives please see Appendix X.

Criteria

The criteria for evaluating the quality of product will be similar to those in Appendix VIII. Criteria which will be used for evaluating process will require development because these criteria presently are not specified nor are they in common use. An example of criteria applicable to
the behavioral objective related to posture will be as in Figure 12.

The Learning Strategy

The learning strategy selected for this instructional and evaluative model is the guided method supported by Ausabel (1963) and Skinner (1968). Vann et al. (1981) found that the guided method produced improvements in quality. Singer (1972) suggested that where highest quality is desired the guided method is the most appropriate.

Psychomotor instruction in preclinical tooth preparation is characterized by a higher degree of precision. A dimension of 0.25 mm is discernable and a dimension of 1.00 mm could mean the difference between success or failure. On some teeth, such as mandibular incisors the distance from the surface of the tooth to the pulp may measure only 1.50 mm. Tooth preparations on teeth as small, dimensionally, as lower mandibular incisors require careful sequencing and step by step development. It is for tasks as detailed as this, that Singer (1972) suggests instruction in a highly guided method.

The significance of selecting this method of instruction to the evaluative process is that the highly guided method requires substantial structural feedback. This structured feedback can be best communicated if explicit behavioral objectives are set for the learner. In turn, the behavioral objectives should be used to design the test items to be evaluated. These relationships strengthen
## Posture

<table>
<thead>
<tr>
<th>Chair Adjustment</th>
<th>Posture During Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highly Acceptable</strong></td>
<td>Same as acceptable but maintain 75% - 100% of the time.</td>
</tr>
<tr>
<td><strong>Acceptable</strong></td>
<td>The seat height allows even distribution of support on the spine and feet. The chair is positioned close to the manikin permitting access to the tooth and instruments without undue reaching. This is maintained 50 - 75% of the time.</td>
</tr>
<tr>
<td><strong>Unacceptable</strong></td>
<td>Same as acceptable but maintained less than 50% of the time.</td>
</tr>
</tbody>
</table>

Figure 12

Criteria for Posture
the validity of evaluation. In connection with this type of evaluation, very well defined criteria or standards must be set and used by both staff and students.

Feedback is also dependent on factors such as instructor availability. In preclinical laboratories the staff-student ratio is approximately 1:16. Each instructor must make himself equally available to all students.

Report of a Pilot Study

While at the University of Toronto, Faculty of Dentistry, during the years 1975 to 1980 this author coordinated a preclinical course in tooth preparation. Initially the course instructional programs and evaluation methods were contained in a traditional manner. This consisted of no specified behavioral objectives, no skills identification, no explicit criteria specification and only minimal instructor training. The emphasis in evaluation was on the product of performance. Students were assigned a grade for each day's performance on the quality of the tooth preparation which was completed.

There was little opportunity for practice without grading; there was a generalized approach to standards and as a result the basis for grading and evaluation was not understood by the students. This resulted in considerable frustration and stress amongst the class members. They were required to produce a product without being specifically instructed in the skills which would permit them to complete an acceptable result. When students were identified at the
end of a course as lacking in manual dexterity ability, the decisions were based on subjective instructor evaluations. Students felt that they entered the course without knowing exactly what the course objectives were and if promoted or held back they did not know why their performance was considered adequate or inadequate.

The part-time instructors were well-meaning general practitioners who had from five to fifteen years of private practice experience. It was evident during grading sessions that what appeared conservative to one instructor was grossly liberal to another. Some consistency was provided during evaluation of product by rotating the instructors amongst the class groups.

During the summer of 1978 and the first semester of the academic year a major revision of this program was undertaken. Although the work sample remained reasonably the same in quantitative and qualitative requirements, all other aspects were altered.

Student outcomes were specified in behavioral terms. Objectives were differentiated between cognitive and psychomotor aspects of the course. Explicit criteria were introduced in order that students and staff would know what was being assessed and how it was being assessed. Sample models were provided of the expected tooth preparations.

Process of performance was emphasized to a greater extent by requiring the staff to observe, as well as, demonstrate in seminar form the various skills which were
essential to tooth preparation. Students were allowed to practice and to correct errors without the stigma of grading every time they touched their instruments. Evaluation was on the basis of practical tests which were designed to primarily test a student's psychomotor skills.

Samples of the course outline, practical examinations, scoring sheets, criteria information, and daily progress sheet are provided in Appendix X.

In addition to the formal organization of the course there were logistic problems which were solved with pragmatic management.

Since the main source of feedback was the instructor, several problems were recognized related to instructor availability.

Preclinical laboratory sessions would be scheduled for a three hour period. There was always a tendency for instructors to be absent for a "coffee break" at a time when the students were in need of direction. This period was usually mid-session and although there were always instructors left to answer student questions it appeared that most students would arrive at this evaluative point in their tooth preparations together. Lengthy queues would form waiting for the few instructors present in the laboratory. As a result, it was decided to implement, on a trial basis, a mandatory break period at mid-session. This would allow everyone the same access to instructors and instructors would have their coffee interludes fostering a
stronger group identity.

Another problem of instructor accessibility was related to certain instructors spending a disproportionate amount of time with only a few students in each group. To improve the instructor accessibility for all students, the instructors were requested to circulate within their respective group of students providing feedback and assistance continuously.

Students also benefitted from the mandatory break although initially some students (the "eager ones") complained about what to them appeared an interruption. They soon realized that no student had an advantage yet every student benefitted by recognizing faults in their projects. There seems to be an ability to view one's work more objectively after some time interval. Students would return to their tooth preparation task with what dental technicians have termed "fresh eyes." Their ability to self-evaluate deficiencies in their work was markedly improved.

To allow students practice time, guidelines related to course progress were provided but no penalty was assessed if a student did not meet these guidelines. Those students who did not achieve the goals would be provided with additional practice time which was termed neither "make-up" nor "remedial." Students who completed their projects, quickly, were given the option of;
1. repeating a similar project exhibiting a different context;
2. proceeding to the next project provided they had sufficient conceptual familiarity with the project; or
3. assisting their peers with comments and suggestions.

The last option was withdrawn early in the program because it became apparent that the capable students were in danger of being subtly ostracized from their peer groups. These capable students were perceived by their peers as "teacher's pets."

Evaluation of student performance was implemented through practical tests. These tests were designed providing knowledge about the projects, thus only the student's psychomotor skills would be assessed. If the cognitive information is not provided then a product may be evaluated and considered unacceptable; but there would be no way of determining whether the error was in concept or in execution. Concepts were tested in a paper and pencil test.

Students would perform their tests with a clear understanding of the marking scheme. They knew what the weighting of various components was. The staff had hoped that the tension of an examination would be lessened by providing a less formal environment. One thought was that music could be provided by means of the public address system. Although most of the students were in favour of
this type of environment a few objected. It was decided not to provide the music.

During the test only a sufficient number of proctors would be left in the laboratory to answer questions or to ensure that independent work was being produced. The remaining staff would use this time to meet in order to assure that everyone agree on criteria and understanding the application of marks. Sample products of performance were provided which depicted most of the variations which the students might create.

When the entire class had completed the test the products, consisting of tooth preparations, were numbered and randomly assigned in order that confidentiality would be maintained. This was especially essential when it appeared that each instructor displayed some degree of positive or negative bias toward students. The instructors, now performing as evaluators, examined the work-samples. Marking schedules were used to record what was observed as acceptable or unacceptable and a score was assigned. Since it was possible for an evaluator to have in his samples all the products with a high score or, on the other hand, all the low scores, the evaluators would then examine each other's group of samples as a comparison. Each evaluator would then circulate to the other evaluator's marking area to obtain some calibration of what was high or low in marks. They would then return to their own marking area and effect any appropriate change in marks. Although this
procedure appears to be a rank ordering method of assessment the rank ordering is used only to calibrate the evaluator. Any tooth preparations which were considered a failure or highly acceptable were evaluated a second time with a new marking guide in order to elicit another opinion.

If the two evaluations were supportive the grade was confirmed. If the two evaluations differed markedly then the course coordinator or another experienced course full-time staff member would be used for a confirming opinion.

In concluding this description of a pilot study, it should be noted that there was no statistical evidence gathered as to whether students or staff observed any strengths or weaknesses. The only subjective input received were the comments of students or staff obtained in either formal or informal discussion. Many features of this model of evaluation received positive comments. The criticisms were of a constructive nature and where possible adjustments were made to the model in the following year.

This pilot study has now been in operation for four years without any substantial alteration.
CHAPTER IV

DISCUSSION

Introductory Statement

Preclinical evaluation of psychomotor tooth preparation skills has many significant components which required further detailed study. In synthesizing this presentation the author realized that each component could constitute a study in itself. Nevertheless it was considered necessary to the conceptual development of this model to present findings from as diverse areas as educational measurement to preclinical instructor characteristics.

The identification of sub-skills associated with psychomotor performance in tooth preparation has rarely been reported. Many dental procedures are identified as consisting of a psychomotor component. However there have been few occasions where these dental psychomotor skills have been related to psychomotor factors as described in Harrow's Taxonomy.

Although considerable study of psychomotor behavior has been reported in the psychological and physical education literature the psychomotor studies in dentistry have usually centered on the product of performance. This obsession with the quality of product is understandable in professions where the excellence of human performance is deemed just adequate. Dental operations consist of minute,
discreet surgery and restoration of one of the smallest human organs. This precision of performance is essential in practically all fields of human health care, for example: brain surgery, eye surgery or cardio-vascular surgery.

Areas for Further Study

During the acquisition of these practical skills, if greater emphasis was placed on observing, evaluating and instructing process of performance there would be immediate benefits to the learner and the institution (Vann et al., 1981). The individual would learn the procedures more efficiently and therefore would have time to spend on other aspects of his course of studies. The institution would benefit from an improved accountability as well as having a better chance for accreditation.

This model although similar to the model at the University of Toronto should have the advantage of a guided strategy as well as a structured feedback mechanism. Because the model at the University of Toronto appears to be meeting the needs of the students and staff there is justification for implementing this model and to examine whether this model of evaluation would have a significant advantage over a traditional approach. There would be considerable merit thereof to carry out a quasi-experimental study of the University of Toronto model and compare the Toronto model with one which is of a traditional nature. Although there would be many variables because of the
differences which exist between various dental schools nevertheless a substantial amount of data related to how staff and students perceive the method of instruction and evaluation could be acquired. Administrators often prefer quasi-experimental studies which are more realistic and relate to courses of instruction which are actually being provided. Very controlled studies do not always have a pragmatic or practical application and hence are not as desirable to educators.

The problem described in this thesis was to identify the factors which would contribute to the most effective evaluation of psychomotor skills in tooth preparation. Through this integrative study it is possible to say that there are effective means available by which psychomotor skills may be assessed. These means consists of first establishing instructional objectives. These objectives are identified by observation of a psychomotor task as well as an analysis of the skills necessary to complete the task. Task analysis informs us as to what has to be performed while skills analysis tells us the how of this performance. Objectives should be linked to observable behavior. In this manner it is possible to design tests and evaluative procedures which are directed to what the individual has learned.

The topic of identifying dental psychomotor skills in addition to those in tooth preparation requires further clarification. There are reports of dental procedures and
what is required; however, the establishment of how these procedures are to be learned and evaluated requires further study. Possibly some of this inadequacy exists because to those in the profession and dental teachers these skills appear self-evident.

The consideration of time in the context of psychomotor performance poses some interesting questions. It has been observed that individuals vary in the time required to acquire a skill. Could some of this variation be due to the learning strategy? The traditional approach to psychomotor instruction has been to depend heavily on discovering learning taking place. Vann et al. (1981) have shown that a highly guided method of instruction provided no benefits in time of acquisition. On the other hand there appeared to be significant improvement in the time of performance. Although a student should have the chance to practice extensively there is some merit in assigning a time factor to the student's performance. This can be achieved by means of practical tests which require that a specified task is completed within a specified time (Appendix X). It is possible only by means of a timed psychomotor performance to identify that a skill is demonstrated (Salvendy et al., 1973). In preclinical psychomotor skills there are not many baseline studies which provide some time of performance under various conditions. This could form the basis of significant research.
Considerable importance is attributed to the instructor's characteristics as part of the evaluative system. Although many studies (Vann et al., 1981) demonstrate the inadequacies of instructor evaluations few studies describe solutions to this problem. One means that is used to improve evaluator consistency is to provide a means of calibration. There have been few studies which specifically assess the effectiveness of various means for calibrating preclinical instructors.

Other aspects of evaluators on student performance are also of interest. What characteristic do students perceive as necessary in a skilled evaluator? At the same time can students truly benefit from instructors who demonstrate only the ideal personality traits? There may be merit from the perspective of inter-personal relations to expose the student to varying personality encounters; or maybe not. These questions also could form the bases of additional studies.

Implication of Study

Although this study was primarily directed to preclinical psychomotor evaluation there are significant implications for this study in clinical situations. Preclinical skill development has a natural progression into clinical skills (see Figure 13). There appear to be similar difficulties identified in this study in assessing student clinical performance.
The Relationship of Preclinical Psychomotor Skill Performance to Stages in a Dental Student's Development

Objectives of Instruction

1. Background Knowledge
2. Basic techniques to clinic entry level
3. Basic technique transfer to patient treatment
4. Minimum clinical competence (Program electives)
5. Problem solving, self-assessment situation unique comprehensive care

Stages of Skill Development

1st Yr.
2nd Yr.
3rd Yr.
4th Yr.

Figure 13

459°
The description of the factors associated with the problems limited to this dental skill has required considerable detail. Nevertheless, the dental skill in question was amenable to the educational principles of evaluation in general (Gronlund, 1966). It should not be impossible, although far more complex, to similarly describe the ingredients of clinical evaluation.

One of the most significant implications is that process should be included for assessment to a greater degree (Mescher et al., 1981; Vann et al., 1981). Dentistry's reliance on evaluation of product of performance does not provide the broad basis for evaluation of preclinical and clinical skill. As a result, there is a need to re-examine the basis of preclinical and clinical programs. If process is facilitative to the learning of psychomotor skill this should be confirmed through further studies.

The major implication associated with the report of the pilot study is the realization that this model which presently exists at the University of Toronto should be subjected to a formal assessment of effectiveness. There are sufficient programs at different Faculties of Dentistry which could be used for comparison. It would be unfortunate not to have some hard data on this model before some changes are instituted.
CHAPTER V

SUMMARY

Tradition often enshrines a methodology, which is obsolete, with a validity, respect and support which is undeserved. This is well illustrated in this thesis study which examines the problems associated with the evaluation of a preclinical psychomotor skill. The problem first became evident from the comments and reactions of students in a dental course which provided instruction in laboratory tooth preparation. These, less than positive responses, assisted staff members to focus attention on problems of instruction and evaluation of these psychomotor tasks. Since this course of study had remained virtually unchanged for many years staff members assumed that there were no major difficulties with course content, methodology or evaluation. However, students experienced an inordinate level of frustration and anxiety during the program. This was partially due to objectives which were not behaviorally nor precisely stated. Students did not feel well-informed about the course requirements and outcomes. Evaluation was on a daily basis and was provided continuously so that students were in fear of making any error. There were few opportunities to practice the manual dental skills because the number of required exercises were numerous.

This thesis addresses these problems by enunciating
several objectives. These were:

1. To identify the purposes of preclinical evaluation of psychomotor tooth preparation skills.
2. To identify the sub-skills within this area of instruction.
3. To set behavioral objectives required of the learner.
4. To identify the products or processes which should be evaluated.
5. To specify criteria for the products and processes which can be evaluated.
6. To determine the evaluative methodology.
7. To define the characteristics which evaluators should display.
8. To demonstrate feasibility of approach in a pilot study.

Certain assumptions and limitations are delineated. This study refers only to intra-coronal tooth preparations as provided in a preclinical psychomotor task. Cognitive aspects of the task are not included. Proper instrument design for efficiency is assumed. Key words are identified and provided with definitions. There are terms such as: measurement, evaluation, formative evaluation, summative evaluation, reliability, validity, objectives, norm-referenced evaluation, criterion-referenced evaluation, rating scale score, skilled movement, skilled response,
abilities and preclinical dental instruction. The most important terms in this list are skilled response and abilities. Skilled response is defined as a response in which receptor-effector-feedback processes are highly organized both spatially and temporally. Spatial temporal patterning, the interplay of receptor-effector-feedback process and such characteristics as timing, anticipation and the graded response are thus seen as identifying characteristics of skill (Sage, 1971). The definition of abilities is that these are inherent, given characteristics of an individual (Fleishman, 1972).

Since this is an integrated study reliance for information is almost exclusively on the reports of other studies. Source material was selected on the basis of relevance, quality and currency. The review of this literature was presented in an order which provided solutions to the stated objectives. In the literature related to the purpose of preclinical evaluation the reports of authors such as: Lutz and Mast (1975), Patridge and Mast (1978), and Forehand et al. (1982) suggest that the main purpose served is:

1. To measure terminal competency;
2. To provide learner feedback; and
3. To provide information about the instructional program.

The literature related to identifying sub-skills in psychomotor tooth preparation consisted of works by Salvendy

The findings from these papers are that time has a significance to skilled performance from two aspects: time of acquisition and time of performance. The significant skills presented necessary to perform the task of tooth preparation are:

1. The skill of maintaining proper posture.
2. The skill of maintaining hand steadiness.
3. The skill of identifying appropriate feedback cues.
4. The skill of responding to the cues received in a proper manner and at the correct time.
5. The skill of maintaining a proper hand grasp on an instrument.
6. The skill of guiding an instrument through precise finger movement or through the exertion of precise finger pressure.
7. The skill of moving a foot at the same time that the hand is performing a controlled movement.
8. The skill of visually tracking over very precise circumscribed distances, accurately.
9. The skill of identifying spatial relations in very fine dimensions.
The works of Prentice, Metcalf (1974), Mager (1962), United States Department of Health Education and Welfare (1972), Mühich (1976), and Gale et al. (1976) are examined regarding the setting of behavioral objectives for learners. The conclusions arrived at were that statement of an objective should contain a stimulus, a response and a condition. Objectives are useful to improve evaluative validity. Student and staff have a guide as to what outcomes are anticipated and under what conditions.

A method of providing a model of evaluation is provided in the following principles (Gronlund, 1966):

1. Determining and clarifying what is to be evaluated always has priority in the evaluation process.
2. Evaluation Techniques should be selected in terms of the purpose to be served.
3. Comprehensive evaluation requires a variety of evaluation techniques.
4. Proper use of evaluation techniques requires an awareness of their limitation as well as their strengths.
5. Evaluation is a means to an end and not an end in itself.

Determining what has to be evaluated offers us the following options to evaluate:

1. product of performance,
2. process of performance,
3. both product and process of performance.

Studies related to product evaluation reviewed are those by: Houtz and Kress (1973), Hinkelman and Long (1973), Lilley et al. (1968), Schiff et al. (1975), Salvendy et al.
(1976), Salvendy et al. (1975), Dilley et al. (1978), Salvendy et al. (1976), Shugars (1981), Lividatis et al. (1976). These studies help to confirm that product has and continues to be the major aspect evaluated in tooth preparation; that product evaluation does not recognize how a learner arrived at his goal and therefore provides minimal feedback of process; that during production evaluation it is difficult to control evaluation variance, thus consistency; that the rating scale should consist of as few intervals as possible; and that some factors of product evaluation are critical to the overall acceptability of the work sample.

The sources of process of performance evaluation were Mescher (1982), Merrill (1972), Mackenzie (1973), Shugars et al. (1981), United States Department of Health Education and Welfare (1972), and Gold (1972). A summary of these authors' findings is that process evaluation requires complex observations and the use of checklists; that process evaluation is subject to environmental variations and that an examination of interim product provides only a rough approximation of process. Articles on the subject of dental process evaluation are few in number. This may be a very desirable area for research studies.

The literature pertinent to specifying criteria and standards was provided by: Levine (1978), Charbonneau et al. (1981), Jordan (1980), Salvendy et al. (1973), and Dhuru et al. (1978). They all concur that criteria are necessary and helpful to the learners and evaluator. Some criteria of
product are already established and accepted (Appendix VIII). The area which presents the greatest potential for criteria establishment is in process evaluation. Some initial progress in this area has been accomplished in courses of dental hygiene (Mescher et al. 1982).


The implication of these articles is: that evaluation should be on a broad basis including product and process, that it should be in conjunction with instruction which is highly guided, containing informational feedback, that evaluation should be on a rating scale from three to five and that the evaluative methodology should be considerate of the evaluator.

An examination of the material which discussed instructor evaluator's characteristics indicated that clinical and preclinical instructors as well as being evaluators provided the role of observer, judge, teacher, assistant and role model. Instructors displayed variance which affected student grades. They are also subject to personal bias and that a likable friendly attitude could
potentially improve performance. If an instructor punishes a student by criticism, inappropriate marking or avoidance, the student's performance will reflect unacceptable quantity or quality features.

Student concerns about evaluator skills were not indicated in any of the studies which consisted of: Koeningburg (1975), Mackenzie et al. (1979), Wigton (1980), Mescher and Kerber (1982), and Holder, Drasgow and Pierce (1976). Articles examined from a secondary source were Cotsonas and Kaiser (1963), Jacobson (1965), Jacobson (1966), Carkhuff (1969), Mayberry (1973), Stritter and Grimes (1975), and Emling and Fritz (1978). These were obtained from the article by Daggett et al. (1979).

Description of the Model

A model for evaluating psychomotor tooth preparation skills is presented and embodies the following recognized elements:

1. to provide feedback to the student about the quality of his performance and about the rate of his skill acquisition;
2. to provide information about the instructional program;
3. to provide assessment of the student's level of performance for promotion;
4. to assist the student with learning how to self and peer-evaluate.
The skills recognized as necessary for psychomotor tooth preparation are:

Primary Skills
1. The skill of maintaining proper posture.
2. The skill of maintaining hand-steadiness.
3. The skill of identifying appropriate feedback cues.
4. The skill of responding to the cues received in a proper manner and at the correct time.
5. The skills of maintaining a proper hand grasp on an instrument.
6. The skills of guiding an instrument through precise finger movement or through the exertion of precise finger pressure.
7. The skill of moving a foot at the same time that the hand is performing a controlled movement.
8. The skill of visually tracking over very precise circumscribed distances accurately.
9. The skill of identifying spatial relations in very fine dimensions.

Secondary skills
1. The skills of instrument assembly.
2. The skill of adjusting the operatory light.
3. The skill of instrument transfer.
4. The skill of completing an operation within a reasonable time frame.
An example is provided by stating behavioral objectives as well as using criteria which specify levels of student performance. A more comprehensive list of these objectives and criteria is provided in Appendix X.

The learning strategy which should be used in conjunction with the method of evaluation is a highly-guided methodology as opposed to a discovery method.

A pilot study is presented with appended course material to provide additional detail on evaluating forms, objectives criteria and method of evaluation. The features unique to this model are that the objectives are specified in relation to psychomotor skills not in relation to product of performance. As a result certain aspects of process are included in the evaluation procedure. Critical error factors have been also recognized in the tooth preparations (product) thus enhancing a student's understanding of the weighting of various cavity preparation criteria. The model employs practice time for skill acquisition as well as tests. The tests also are weighted in order that the student may not be punished in the early stages of the program. It is in the early stages of the program during which the student has to learn what the cues, standards and objectives consist of.

Another feature of uniqueness is that this model suggests the use of flexible interpretation of what should be evaluated. Since the evaluation is that of a psychomotor entity the early evaluation addresses the need for knowledge
and knowledge integration. The intermediate phase approximate midpoint of the semester evaluators are requested to observe students' ability to recognize cues to better performance and incorporation of this skill in their approach to carrying out the task. Finally to recognize skilled performance at the end of the course the emphasis is to observe the automatic nature of the performance.

Conclusions

This model of evaluation has a potential for comparison of effectiveness since the pilot study appears to be in continuous operation over the last four years. Although there appears to be general acceptance of the features of the model it would be interesting to have some statistical data supporting strengths and weaknesses.

Process skills, objectives and criteria hold considerable potential for further development in this area of psychomotor skill development. The aspects of process and their importance to feedback are recognized. What is required is a systematic classification of process skills applicable to the dental psychomotor performance.

Time of acquisition as well as time of performance are in need of additional study to indicate their relationship to psychomotor skills as reflected in product quality. There is some suggestion that time of performance is traded off for accuracy in certain situations (Stubbs, 1976).
If the factors which contribute to effective psycho-motor preclinical skills evaluation are identified these are significant and valid applications of these factors to clinical evaluation. This would result in benefits not only to the learner but also to the teaching institutions, the profession and the public.
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APPENDIX I

Old and New Educational Premises
Appendix I

Old and New Educational Premises

I. The old educational premise holds that a core of knowledge should be taught. No one learns anything in the same time; some students are quicker, others slower at learning. Yet, colleges and medical schools have made the body of knowledge and the time taken to study it identical in all respects. Failure is therefore built into the present system.

A new educational premise would emphasize eliciting a core of behavior from a student rather than rote memorization. By beginning with simple tasks, students would learn by doing and would then see the immediate relevance of their learning.

II. A second old educational premise holds that the faculty, research, and teaching facilities are the principal resources of a university, and especially the medical school. The underlying assumption of this premise is that large capital investment is required including large research facilities, many faculty members, and big budgets. This is essentially an outgrowth of the necessity to memorize knowledge. When knowledge is emphasized, the facilities that produce more knowledge become of primary importance.

A new premise should be that the greatest resource of the university is the student's capacity to solve problems on his own, using all of the tools available. Universities tend to foster dependency among students rather than encouraging independent thought. The student is the largest untapped resource of a university.

III. The third old assumption is that the student should learn facts and develop understanding in the absence of real work and responsibility. There is no real risk for students, no real involvement, and, hence, no real feeling of responsibility for their work.

The new premise holds that real work and responsibility should form the basis of all educational activities from the beginning. This view implies that students should be given progressively more difficult problems to solve according to their abilities. Once students have mastered each step, they can progress to the next stage. The present
IV. The fourth old premise implies that time and the number of courses should be the constant and the achievement the variable. Time is apportioned equally, not according to the importance of subject matter but according to how well it fits into a four-year course load. This means that achievement is a variable and the number of tasks and time spent in learning the constant.

The new premises would reverse this view by stating that achievement should be the constant and time and the number of tasks the variable. It is better to learn one thing and do it well than know how to do many things badly. The student should be made to learn one task and do it superlatively before progressing to the next task.

V. The fifth old premise assumes that the examinations should be taken at one particular time in order to qualify people to practice their professions. Further, this assumption implies that grading these examinations and rewarding A's, B's, and C's is somehow meaningfully related to how well a person will perform in his chosen profession.

The new premise states that a person's performance should be audited at random intervals throughout life according to educational goals and clearly defined rules.

To assume that paper-and-pencil tests bear some relationship to real work is as erroneous as is assuming that knowledge somehow equals performance. We assume the student has mastered the subject matter. However, knowledge and technologies change rapidly. The only certainty is the student's developed ability to solve problems.

Based on these new educational premises the PROMIS Lab identified three basic needs of a sound educational system.

First, educational goals should be clear so that students know what is expected of them.

Second, performance rather than rote memory should be emphasized.

Third, some form of central record system to store and retrieve knowledge is necessary.
APPENDIX II

G.V. Black's Principles
PROXIMO-OCCULSAL CAVITIES IN THE BICUSPIDS AND MOLARS.

OUTLINE FORM. It will usually be more convenient to prepare the outline form of the occlusal surface in advance of the proximal portion, although in cases in which the decay is extensive the proximal portion should be prepared first. In cases in which the decay has undermined the occlusal enamel, it should first be removed sufficiently with a chisel to give room for a 1 mm. inverted cone bur. A series of cuts should then be made along a groove to the nearest occlusal fossa or pit. These cuts should be made as described for occlusal cavities and should be continued, by undermining and breaking out more enamel until the general form of the occlusal step has been obtained. See Figure 319.

In cases in which there is no decay of the occlusal surface, an opening should be made through the enamel with an 8 tenths to 1 mm. inverted cone bur in a fossa that will necessarily be included in the cavity outline. The opening may be enlarged, if necessary, and the same bur should be used to make a series of cuts along the line of the groove to connect with the proximal decay. The walls of the step should be trimmed to form with suitable chisels or hatchets.

In the proximal portion of the cavity, all undermined enamel should be cut away. Hatchets 18-9-12 or 12-6-12 may be used for the buccal and lingual walls. See Figure 344. When there is proper access, the buccal and lingual enamel may be cut more readily from the buccal and lingual directions. For mesial surface decays, the straight chisel 12 may be used from the buccal and the hatchet (right or left) 12-6-6 from the lingual. See Figures 345 and 346. For distal cavities, chisel 12-6-12 may be used from the buccal for bicuspid and the first molar, the 12-6-23 from the buccal for the second molar and from the lingual for most of the bicuspid and molars. Positions of these instruments are shown for a distal cavity in the second bicuspid in Figures 347 and 348.

If further extensions require the cutting of a little sound dentin and enamel, an inverted cone bur is used in much the same manner as for occlusal extensions, except that there is no groove to follow. It is necessary to undermine, by cutting in the dentin, whatever enamel is to be removed. As a rule more cutting is required at the bucco-gingival and linguo-gingival angles than elsewhere. An 8 tenths mm. inverted cone bur may be pressed, while rotating slowly, into the dentin just beneath the enamel of, for example, the bucco-gingival angle, and then pressed laterally.
through the enamel to the surface. This may be repeated until the desired position of bucco-gingival marginal angle is reached. See Figure 349. Similar cuts may be made at the linguo-gingival. The bur may then be drawn occlusally in the dentin, undermining the enamel to extend the buccal and lingual margins. A cut may then be made at the gingival, from buccal to lingual, connecting the cuts previously made, in extending the bucco-gingival and linguo-gingival angles. Hatchets should then be used to trim the buccal, lingual and gingival walls. This completes the outline form.

**RETENTION AND RESISTANCE FORMS** may be obtained by the use of a bur, as in the occlusal portion of the cavity, by cutting the gingival wall in the horizontal plane. The 12 angle hatchets are then used to cut the surrounding dentin walls to proper form. In no case should the pulpal, gingival or axial walls be cut deeper than is absolutely required; usually less than 1 mm. into the dentin. Deeper cutting endangers the pulp without advantage to the restoration. The line angles of the proximal portion should be made very definite. The chisels and hatchets may be used for all of these, or the margin trimmers may be preferred in some cases for the axio-buccal, axio-lingual and axio-gingival line angles. The instruments with the cutting edge of the blade at 80° angle may be used for distal cavities, and the 95° angle for the same line angles in mesial cavities. This use of one of the 95° angle instruments is illustrated in Figures 350 and 351. The hatchets illustrated in Figure 291 were especially designed for this purpose by Dr. Hartman. All walls in axial planes must be inclined slightly outward in preparations for inlays. For gold foil or amalgam they should be cut in the axial planes, with opposing walls parallel, or these walls may in some cases be slightly undercut.

**STARTING POINTS FOR GOLD FOIL.** When the smaller cavities of this type, most often in mesial surfaces, are prepared for gold foil, the starting points should be placed in the pulpo-disto-buccal
and pulpo-distal-lingual point angles, also in the gingivo-axio-buccal and gingivo-axio-lingual angles. See Figure 323.

CONVENIENCE FORM. No convenience form would usually be required for the cavities of this class.

REMOVAL OF REMAINING CARIOUS DENTIN. Except in rather large cavities, the carious dentin would have been entirely removed in the preceding preparation of the cavity. If any remained, it should be removed with a spoon of convenient size, and should be replaced with cement, rather than cut the cavity deeper.

FINISH OF THE ENAMEL WALL. The enamel walls of the occlusal step should be finished the same as for the occlusal cavities. All of the walls of the proximal portion should be made smooth with the 12 angle hatchets. See Figures 352A and 352B. The direction of the rods requires that the buccal and lingual enamel walls be slightly inclined outward, which can be done with the same hatchets. The margin trimmers, cutting edge angle of 80, are used for the gingival, buccal and lingual walls of mesial cavities, the 95 angle for distal cavities. Each of these instruments may be used effectively to trim margins of two walls. For example, the left instrument, angle 80, will trim the margin of the lingual wall of a mesial cavity in a lower right molar, cutting from occlusal to gingival, it will also trim the lingual half of the margin of the gingival wall, cutting from buccal to lingual. See Figures 353 and 354. In making both cuts it should be carried a little past the angle to make the marginal outline very slightly curved. This same pair of 80 angle, are also very convenient to bevel the cavo-surface angle of the distal wall of a mesio-occlusal cavity, and the 95 angle to bevel the cavo-surface of the mesial wall of a disto-occlusal cavity.

THE TOILET OF THE CAVITY. The toilet of the cavity should be made with the cavity dry, as has been described. If a gold foil or amalgam restoration is placed or a pattern is made for an inlay. Then before the inlay is cemented, the surfaces of the walls should be scraped with very sharp instruments and light pressure, without cutting the enamel, to clean the walls.
APPENDIX III

Differences between Criterion-Referenced and Norm-Referenced Measures
### Appendix III

#### Table 1

**Differences between Criterion-Referenced and Norm-Referenced Measures**

The differences summarized below are in most cases matters of degree rather than kind

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Criterion-Referenced Measures</th>
<th>Norm-Referenced Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Intent</td>
<td>Degree to which absolute external performance standards have been met</td>
<td>Information for relative internal comparisons</td>
</tr>
<tr>
<td></td>
<td>Description of maximum performance by individuals, groups, and treatment</td>
<td>Comparisons of individuals, particularly when high degree of selectivity is required</td>
</tr>
<tr>
<td>2. Directness of measurement</td>
<td>Great emphasis</td>
<td>Lesser emphasis</td>
</tr>
<tr>
<td>3. Variability among scores</td>
<td>Relatively low</td>
<td>Relatively high</td>
</tr>
<tr>
<td>4. Difficulty of items</td>
<td>Items tend to be easy, but with some range</td>
<td>Item difficulty localized around 50%</td>
</tr>
<tr>
<td>5. Item type</td>
<td>Great variety, but less reliance on selection-type items</td>
<td>Variety, but emphasis on selection-type items</td>
</tr>
<tr>
<td>6. Discriminating ability of item</td>
<td>Not emphasized</td>
<td>Greatly emphasized</td>
</tr>
<tr>
<td>7. Methods of establishing validity</td>
<td>Reliance on content validity</td>
<td>Emphasis on criterion-related validity</td>
</tr>
<tr>
<td>8. Emphasis on reliability</td>
<td>Focus on reliability of domain sampling; therefore internal consistency of some interest</td>
<td>Greater concern with parallel form and test-retest estimates of performance stability</td>
</tr>
<tr>
<td>Dimension</td>
<td>Criterion-Referenced Measures</td>
<td>Norm-Referenced Measures</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>9. Influence of guessing</td>
<td>Can be of consequence</td>
<td>Generally not a problem</td>
</tr>
<tr>
<td>10. Importance of High which items are missed</td>
<td></td>
<td>Emphasis on number of missed items</td>
</tr>
</tbody>
</table>
APPENDIX IV

Summary Outline of Psychomotor Taxonomy
Appendix IV

Summary Outline of Psychomotor Taxonomy

1.00 Reflex Movements
   1.10 Segmental Reflexes
      1.11 Flexion Reflexes
      1.12 Myotatic Reflex
      1.13 Extensor Reflex
      1.14 Cross Extensor Reactions
   1.20 Intersegmental Reflexes
      1.21 Cooperative Reflex
      1.22 Competitive Reflex
      1.23 Successful Induction
      1.24 Reflex Figure
   1.30 Suprasegmental Reflexes
      1.31 Extensor Rigidity
      1.32 Plasticity Reactions
      1.33 Postural Reflexes
         1.331 Supporting Reactions
         1.332 Shifting Reactions
         1.333 Tonic-Attitudinal Reflexes
         1.334 Righting Reaction
         1.335 Grasp Reflex
         1.335 Placing and Hopping Reactions

2.00 Base-Fundamental Movements
   2.10 Locomotor Movements
   2.20 Non-Locomotor Movements
   2.30 Manipulative Movements
      2.31 Prehension
      2.32 Dexterity

3.00 Perceptual Abilities
   3.10 Kinesthetic Discrimination
      3.11 Body Awareness
         3.111 Bilaterality
         3.112 Laterality
         3.113 Sidedness
         3.114 Balance
      3.12 Body Image
      3.13 Body Relationship to Surrounding Objects in Space
   3.20 Visual Discrimination
      3.21 Visual Acuity
      3.22 Visual Tracking
      3.23 Visual Memory
      3.24 Figure-Ground Differentiation
      3.25 Perceptual Consistency
3.30 Auditory Discrimination
  3.31 Auditory Acuity
  3.32 Auditory Tracking
  3.33 Auditory Discrimination
3.40 Tactile Discrimination
3.50 Coordinated Abilities
  3.51 Eye-Hand Coordination
  3.52 Eye-Foot Coordination

4.00 Physical Abilities
4.10 Endurance
  4.11 Muscular Endurance
  4.12 Cardiovascular Endurance
4.20 Strength
4.30 Flexibility
4.40 Agility
  4.41 Change Direction
  4.42 Stops and Starts
  4.43 Reaction-Response Time
  4.44 Dexterity

5.00 Skilled Movements
5.10 Simple Adaptive Skills
  5.11 Beginner
  5.12 Intermediate
  5.13 Advanced
  5.14 Highly Skilled
5.20 Compound Adaptive Skill
  5.21 Beginner
  5.22 Intermediate
  5.23 Advanced
  5.24 Highly Skilled
5.30 Complex Adaptive Skill
  5.31 Beginner
  5.32 Intermediate
  5.33 Advanced
  5.34 Highly Skilled

6.00 Non-Discursive Communication
6.10 Expressive Movement
  6.11 Posture and Carriage
  6.12 Gestures
  6.13 Facial Expression
6.20 Interpretive Movement
  6.21 Aesthetic Movement
  6.22 Creative Movement
APPENDIX V

Lividatis' Checklist
## PERFORMANCE TABLE

### CLINICAL COMPETENCY EXAMINATION

**CLASS II AMALGAM**

*(100% - 120 Student Examinations)*

<table>
<thead>
<tr>
<th>Performance</th>
<th>Superior</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>Percentage</td>
<td>Percentage</td>
<td></td>
</tr>
</tbody>
</table>

### SECTION I

<table>
<thead>
<tr>
<th>A.</th>
<th>B.</th>
<th>C.</th>
<th>D.</th>
<th>E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. Organization according to sequence of use</td>
<td>91</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>1b. Inclusion of necessary/unnecessary instruments</td>
<td>81</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SECTION II

| E. 1. Improper extension for susceptible fissures | 74 | 5 |
| 2. Integrity of marginal ridge | 82 | 9 | 3 |
| 3. Under extension, occlusal | 98 | 1 |
| Over extension, occlusal | 10 | 8 |
| 4. Under extension, proximal | 82 | 15 | 3 |
| Over extension, proximal | 16 | 10 |
| 5. Under extension, gingival wall | 96 | 1 |
| Over extension, gingival wall | 12 | 3 |
| 6. Elimination of unsupported or decalcified enamel | 88 | 23 | 5 |

### C. 1a. Excessive removal sound dentin, pulpal wall | 82 | 10 |
| 2. Inadequate removal of caries | 98 | 3 |
| 3. Mechanical exposure | 100 |

### D. 1. Improper depth, shallow | 93 | 2 |
| Improper depth, deep | 81 | 15 |

### 2. Proper inclination of walls | 61 | 36 | 3 |

### 3. Proper retention form | 42 | 48 | 10 |

### 4. Proper resistance form | 38 | 28 | 4 |

### 5. Axio-pulpal bevel | 35 | 36 | 5 |

### 6. Finish of enamel walls | 40 | 58 |

### E. 1. Care of adjacent teeth | 98 |

### SECTION III

<table>
<thead>
<tr>
<th>A.</th>
<th>B.</th>
<th>C.</th>
<th>D.</th>
<th>E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Proper selection of liners and bases</td>
<td>76</td>
<td>14</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2. Proper application of liners and bases</td>
<td>88</td>
<td>33</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

### B. 1. Selection and placement of retainer | 85 | 13 | 6 |
| 2. Selection and modification of band | 74 | 15 |
| 3. Contouring of band | 87 | 4 |
| 4. Proper wedging | 36 | 28 |
| C. 1. Cleanliness of cavity | 76 | 24 |

### SECTION IV

| B. 1. Marginal adaptation | 86 | 9 |
| C. 2. Proper height of marginal ridge | 86 | 12 |
| D. 1. Lack of contact | 85 | 5 |
| E. 1. Occlusion | 92 | 7 |

### Automatic Failures on Critical Factors

<table>
<thead>
<tr>
<th>Number of Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate removal of caries</td>
</tr>
<tr>
<td>Mechanical exposure</td>
</tr>
<tr>
<td>Proper application of liners and bases</td>
</tr>
<tr>
<td>Marginal adaptation</td>
</tr>
<tr>
<td>Lack of contact</td>
</tr>
<tr>
<td>Lack of contact</td>
</tr>
</tbody>
</table>

129
APPENDIX VI

National Dental Examining Board Checklist
Appendix VI
National Dental Examining Board Checklist

Restorative Dentistry - Composite Resin or Gold Foil
Clinical Competency Examination Form

Candidate: ________________ Tooth: ______ Surfaces M O D F L

SECTION I - DIAGNOSIS

SECTION II - OPERATORY SET-UP
1. Cleanliness and appearance of counter and tray surfaces
2. Personal cleanliness and Professional appearance

SECTION III
A. Outline form
1. ( ) Under ( ) Over extension
2. Elimination of unsupported or decalcified enamel
B. Cavity Design
1. Depth: ( ) shallow ( ) deep
2. Inclination of walls: ( ) occlusal ( ) gingival
3. Retention form
4. Finish of enamel walls
C. Caries Removal
1. Excessive removal of sound dentin from Pulpal Wall
2. Inadequate removal of caries
3. Mechanical exposure
D. Rubber Dam Application
1. Neatness of application
2. Selection and application of clamp
3. Leakage into work area

SECTION IV - READY FOR RESTORATION
Pulp Protection
1. Application of base if necessary
2. Base material on cavo-surface margins
# SECTION V -- INSERTION, CONTOURING AND CARVING

| A. Marginal adaptation | F
| B. Contour | 
| C. Finishing | 

# SECTION VI -- TISSUE MANAGEMENT -- Gross abuse of tissues

F

# SECTION VII -- UNPROFESSIONAL BEHAVIOR

F

---

F - Automatic Failure  
S - Satisfactory  
E - Excellent  
U - Unsatisfactory
APPENDIX VII

University of Iowa Technique Evaluation:
Instrumentation Section
Appendix VII

University of Iowa Technique Evaluation:
Instrumentation Section

III. Instrumentation

_____ Mouth Mirror

Patient comfort:
- avoids hitting teeth
- mouth corner not stretched
- avoids pinching soft tissue
- retracts out rather than back stabilized

Illumination
Indirect vision

INSTRUMENT __________  __________

Instrument sharp _____

_____ Grasp

Modified, pen grasp
Correct finger tension
Close to shank

_____ Fulcrum

Maintains
- Adjacent to working area
- Hard tissue
- On same arch

_____ Pressure

Light insertion pressure
Light pressure for exploratory stroke
Appropriate pressure throughout working stroke
Uniform pressure throughout working stroke

_____ Adaptation

Rotates instrument in fingers for adaptation
Rotates on fulcrum to aid adaptation
Inserts with tip
Maintains proper angle
Side of tip on hard tissue
Uses maximum amount of working end
Covers all surfaces

Stroke

No working in apical direction
Maintains tip apically during working stroke
Verticle and/or oblique stroke
Short overlapping stroke
No finger motion
APPENDIX VIII
Charbonneau's Criteria
### Rating System for Quality Evaluation of Prepared Cavities

<table>
<thead>
<tr>
<th>RATING</th>
<th>OPERATIONAL EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Meets all Standards of Excellence</td>
</tr>
<tr>
<td>S</td>
<td>Satisfactory with Minor Correction(s)</td>
</tr>
<tr>
<td>M</td>
<td>Satisfactory with Moderate Correction(s)</td>
</tr>
<tr>
<td>T</td>
<td>Major Correction(s) Required</td>
</tr>
<tr>
<td>V</td>
<td>Fundamental Concepts not Demonstrated</td>
</tr>
</tbody>
</table>
### Quality Evaluation Criteria For Prepared Amalgam Cavities

<table>
<thead>
<tr>
<th>RATING</th>
<th>Margins—Definition</th>
<th>Retention</th>
<th>External Outline</th>
<th>Internal Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXTERNAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enamel walls parallel and direction</td>
<td>Retention conspicuous visually and actually</td>
<td>Internal outline extended for convenience, removal of decalcification and contiguous tissues</td>
<td>Complete C.R.</td>
<td></td>
</tr>
<tr>
<td>Walls and margins smooth</td>
<td>Cavity well-defined</td>
<td>Straight lines, smooth curves consistent with tooth form and conservation</td>
<td>No excessive tissue loss</td>
<td></td>
</tr>
<tr>
<td>Slight roughness of cavity walls or margins</td>
<td>Slight lack of cavity definition</td>
<td>Slightly underextended</td>
<td>Pulpal or axial walls slightly shallow</td>
<td></td>
</tr>
<tr>
<td>Slight lack of cavity definition</td>
<td></td>
<td>Slightly overextended</td>
<td>Pulpal or axial walls slightly deep</td>
<td></td>
</tr>
<tr>
<td>Moderate roughness of cavity walls or margins</td>
<td>Moderate lack of cavity definition</td>
<td>Moderately underextended</td>
<td>Slight tissue loss</td>
<td></td>
</tr>
<tr>
<td>Moderate lack of cavity definition</td>
<td></td>
<td>Moderately overextended</td>
<td>Pulpal or axial walls moderately shallow (shades of enamel)</td>
<td></td>
</tr>
<tr>
<td><strong>MODERATELY UNDEREXTENDED</strong></td>
<td></td>
<td>Moderately irregular</td>
<td>Pulpal or axial walls moderately deep (other required)</td>
<td></td>
</tr>
<tr>
<td>Enamel unsupported</td>
<td>Cavity walls or margins rough</td>
<td>Contiguous fissures or decalcification not removed</td>
<td>Pulpal or axial walls with much enamel remaining</td>
<td></td>
</tr>
<tr>
<td>Cavity ill-defined</td>
<td></td>
<td>Supporting tissues unnecessarily traumatized</td>
<td>Pulpal or axial wall entirely in enamel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decidually underextended</td>
<td>Mechanical pain exposure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decidually overextended</td>
<td>Frank tissue remaining</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decidually irregular</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minor damage to adjacent tooth</td>
<td>Grossly underextended</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX IX

Ryge's Criteria
### Quality Evaluation Rating System

<table>
<thead>
<tr>
<th>Rating</th>
<th>Operational Explanation</th>
<th>Code</th>
<th>Surface and Color</th>
<th>Code</th>
<th>Anatomic Form</th>
<th>Code</th>
<th>Margin Integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R</strong> Romeo</td>
<td>The restoration is of satisfactory quality and is expected to protect the tooth and the surrounding tissue.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>S</strong> Sierra</td>
<td>The restoration is of acceptable quality, but exhibits one or more features which deviate from the ideal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>T</strong> Tango</td>
<td>The restoration is not of acceptable quality. Future damage to the tooth and/or its surrounding tissues is likely to occur.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>V</strong> Victor</td>
<td>The restoration is not of acceptable quality. Damage to the tooth and/or its surrounding tissue is now occurring.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Quality Evaluation Criteria and Abbreviations

- **R** No visible evidence of ditching along the margin.
- **S** No discoloration on the margin between the restoration and tooth structure.
- **SCR** Visible evidence of ditching along the margin not extending to the DE junction.
- **SDIS** Discoloration on the margin between the restoration and the tooth structure.
- **V** VFM Fractured material along the margin of the restoration.
- **VFM** VFM Fractured material along the margin of the restoration.
- **VFS** VFS Fractured material along the margin of the restoration.
- **VPS** VPS Fractured material along the margin of the restoration.
- **VPP** VPP Fractured material along the margin of the restoration.
- **VPR** VPR Fractured material along the margin of the restoration.
- **VPS** VPS Fractured material along the margin of the restoration.

*Criteria apply to anterior restorations.*
APPENDIX X

Pilot Study Course Material
FACULTY OF DENTISTRY
University of Toronto

RESTORATIVE DENTISTRY

FIRST DENTAL YEAR

DEPARTMENT CHAIRMAN & HEAD

: Dr. A. Bruce Hord
   Room 309
   124 Edward Street
   Ext. 8516

COURSE CO-ORDINATOR

: Dr. Carl J. Osadetz
   Room 507
   123 Edward Street
   Ext 2141 or 8516

LECTURES

: MONDAYS: 9:40 to 10:20 A.M.
   Room 108
   TUESDAYS: 1:30 to 2:20 P.M.
   Auditorium

LABORATORY

: MONDAYS: 10:30 to 1:00 P.M.
   Room 51
   TUESDAYS: 2:30 to 5:00 P.M.
   Room 51

DATES FOR COURSE

: MONDAY: January 8, 1979 to
   TUESDAY: April 17, 1979
RESTORATIVE DENTISTRY

1.0 INTRODUCTION

Since a large percentage of the population is affected by dental caries, it is imperative that dental students be trained in the treatment of this disease. At the first year level the students will be introduced to principles, instruments, materials and procedures used in operative dentistry.

The students will perform projects on two-times natural sized plaster teeth in order to conceptualize selected tooth preparations. They will then miniaturize similar preparations on natural sized plaster and ivorine typodont teeth. This will provide the student with an opportunity to progressively refine his or her psychomotor skills in the use of conventional speed rotary instruments and ultra speed rotary instruments as well as hand instruments.

Work position and accessibility problems will be simulated to those encountered clinically by performing projects on models mounted in a manikin head.

The student will be introduced to various dental restorative materials by completing the restoration of cavities previously prepared.

At each stage the students will be expected to correlate their didactic instruction with their laboratory efforts as they systematically proceed through the course.

2.0 TEXT AND MATERIALS

The Department will provide some handouts; however, the bulk of instructional material is contained in the following:

2.

(2.0 Text and Materials continued)

For additional reading the following text is


The Department provides the student with two-times natural sized plaster teeth, a natural sized ivorine tooth typodont, an instrument kit (Appendix 1) and various materials used in this course.

### 3.0 Prerequisites

The student will find that a thorough knowledge of tooth morphology, tooth contact, contour and occlusion is invaluable as a prerequisite for this course.

An understanding and a facility in the use of cavity nomenclature will assure the student of a better comprehension of the lecture course. A self instructional unit (#III) will be provided at the end of November to initiate study in this area.

Dr. G.V. Black's "Classification of Cavities" and "Steps in Cavity Preparation" should be studied as well. (Self instructional Units #I and II).

### 4.0 Objectives (General)

The objectives of this program are twofold:

#### 4.1

Upon completion of the program, students will become proficient in operative dentistry nomenclature, principles of cavity preparation and restoration, as adapted from Dr. G.V. Black; and will demonstrate the ability to perform selected tooth preparations both on over-sized plaster teeth and T660 hard ivorine teeth mounted
3.

4.2 Students will be expected to develop manual skills required for tooth preparation and restoration of simple intra-coronal cavities before proceeding to the more comprehensive program of second Year.

4.3 OBJECTIVES : INSTRUCTIONAL.

The instructional objectives in this course are divided into cognitive and psychomotor.

COGNITIVE

The student should be able to:

(Course Content)

1. Describe the course topics selected.
2. Distinguish the marking and grading scheme used.
3. Identify the criteria used in marking and grading.

(Use and Knowledge of Instruments)

4. Identify and properly name the instruments used.
5. Discuss the proper working positions assumed when operating on a manikin head.
6. Describe the proper instrument hand grasp as well as hand positions used in operative dentistry.
7. Describe the proper use of the hand mirror.
8. Discuss the care and use of various instruments in operative dentistry.
9. Discuss the principles of sharpening hand instruments.
10. Identify handpieces, their parts and their maintenance.

(Controlling the Operative Field)

11. Discuss moisture control.
12. List the advantages and disadvantages of the rubber dam.
13. Discuss the technique of rubber dam placement.
14. Describe the classification of cavities.

(Tooth Preparation)
15. Discuss the principles of cavity preparation.
16. Discuss the steps in cavity preparation.
17. Describe and discuss the cavity features of the selected tooth preparations.
18. Identify the generally accepted configuration of incipient caries in pits and fissures and on smooth surfaces.
19. Identify the proper form and extent of all classes of cavity preparation for the incipient lesion.
20. Describe the technique of preparing each class of cavity.

(Nomenclature)
21. Name the various line angles, point angles and walls of all classes of cavity preparation.
22. Identify the simple, compound and complex cavity preparation,

(Biomechanical Consideration)
23. Describe the effects of operative procedure on the tooth tissues.
24. Describe pulp capping - both direct and indirect - and the materials used.
25. Discuss the reason for the use of cavity varnish.
26. Identify the restorative material under which Zinc Oxide Eugenol preparations should be used.
27. Identify and discuss the proper use of pulp protection agents for cavity liners and bases.

(Cavity Restoration)
28. Describe and discuss the importance of contour, contact,
5. occlusion and embrasure form as related to restorations.

29. Describe and identify marginal integrity.

30. Discuss the polishing of restorative materials.

31. Identify the basic steps in the use of various matrices for amalgam and resin.

32. Discuss some of the material background of each restorative material used.

33. Discuss amalgam alloy with special reference to high copper alloy and the benefits of their use.

(Amalgam)

34. Describe the technique of trituration and condensing amalgam.

35. Describe the techniques of carving, pre-finishing and polishing of amalgam restorations.

(Resin)

36. Describe the techniques for mixing, placing and finishing unfilled resin, composite resin and the acid etch technique.

(Cast Gold)

37. Discuss the requirements for an acceptable cast gold restoration.

PSYCHOMOTOR

The student should be able, within a given time frame, to:

1. Select a designated tooth from a group of teeth.

2. Dissect permanent teeth or models and describe normal form and size of pulp cavity, variations in pulp cavity, relative thickness of enamel and dentine.

3. Demonstrate an ability to identify criteria, classifying various projects as unacceptable, acceptable or highly acceptable.
6.

4. Prepare an ivorine tooth for restoration with amalgam and a Class I, II, III and V simulated incipient carious lesion.

5. Restore and finish an amalgam restoration for the above mentioned class of cavities.

6. Prepare an ivorine tooth, for restoration with auto-polymerizing resin, using an acid-etch technique, a Class III and Class V simulated incipient carious lesion.

7. Place, contour, and finish the above mentioned resin preparations in unfilled and filled resins.

8. Prepare an ivorine tooth for a cast gold Class II simulated incipient lesion.

9. Fabricate, fit and finish a cast gold restoration for the above tooth preparation.

10. Demonstrate the ability to adapt the principles of cavity preparations to various teeth for all the above mentioned procedures.

11. Demonstrate the ability to properly scale dimension on various project teeth of a size other than natural size.

12. Demonstrate the ability to mix and place varnish Zoe, Calcium Hydroxide and zinc phosphate bases and lines as required in the above mentioned tooth preparations.

13. Prepare a sub floor simulating a deep carious lesion.

14. Treat the deep carious lesion with pulp protecting agents properly.
7.

5.0 Course Timetable

By means of lecture, slide demonstration, group seminars and videotape replay presentations, the didactic and preclinical demonstrations will provide the student with the background knowledge to perform the preclinical exercises. The course timetable will be as follows:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture Presentation</td>
<td>24</td>
</tr>
<tr>
<td>Preclinical laboratory sessions (to include V.T.R. and group demonstrations)</td>
<td>60</td>
</tr>
<tr>
<td>Didactic Material Examination</td>
<td>4</td>
</tr>
<tr>
<td>Preclinical technique testing</td>
<td>10</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>98</strong></td>
</tr>
</tbody>
</table>

The course content is according to the following schedule of lectures, laboratory projects, etc. (Schedule A).

**STAFFING**

It has been found that the most favourable staff-student ratio must occur at the preclinical level in order to accomplish the objectives of the program.

Nine part-time staff members have been especially chosen for their wide experience in general practice, ability to relate to students and teaching skills.
8.

Staff are assigned to the same students for a period of six weeks so that both students and staff may benefit from daily consistency in instruction, evaluation and dialogue. At least two staff rotations are made during the program.

EVALUATION

Owing to the subjective nature of preclinical technique course evaluation, the course will base all student evaluation on performance during four written term tests, four practical examinations and one essay. The weighting of the tests and essay is as follows:

<table>
<thead>
<tr>
<th>DATE</th>
<th>ESSAY</th>
<th>WRITTEN</th>
<th>PRACTICAL</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/2/79</td>
<td>4</td>
<td>5</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>18/3/79</td>
<td>6</td>
<td>15</td>
<td></td>
<td>21</td>
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<tr>
<td>26/3/79</td>
<td>10</td>
<td></td>
<td></td>
<td>10</td>
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<tr>
<td>27/3/79</td>
<td>4</td>
<td>20</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>17/4/79</td>
<td>6</td>
<td>30</td>
<td></td>
<td>36</td>
</tr>
</tbody>
</table>

10% 20% 70% 100%

In order to complete this program with a PASS standing it will be necessary for each student to have attained a grade point average of 60% in each component (essay, written, practical) as well as an overall percentage of 60%.
9.

Final grades will be reported to the Faculty Office on the basis of Honours, Pass or Fail.

Any student deemed to have failed the course will have the opportunity to participate in a preclinical program following the regular program which will enable him/her to practise operative procedures in readiness for examination by an external examiner.

This will not be a course of study, but a program of practice, with instructor feedback, in preparation for an external examination.

Having demonstrated his competence by virtue of the external examiner's report, a student may proceed to second year.

If a failure is recorded as a result of the examiner's report, a student is required to withdraw from the course in dentistry.
## SCHEDULE OF LECTURES, LABORATORY PROJECTS AND ASSIGNMENTS

**NOTE:** See abbreviation code at end

**DEPARTMENT OF RESTORATIVE DENTISTRY**

**FIRST DENTAL YEAR COURSE**  
**SCHEDULE OF LECTURES, LABORATORY PROJECTS AND ASSIGNMENTS**

<table>
<thead>
<tr>
<th>DATE</th>
<th>LECTURE</th>
<th>ASSIGNMENTS</th>
<th>LABORATORY PROJECT</th>
<th>SCHEDULED SEMINAR</th>
<th>V.</th>
<th>T.</th>
<th>R.</th>
<th>HAL.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979  1</td>
<td><strong>INTRODUCTION</strong></td>
<td><strong>C. O</strong></td>
<td>Tooth Sections</td>
<td><strong>#1</strong></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>JAN. 8</td>
<td><strong>Course Outline</strong></td>
<td><strong>C. O</strong></td>
<td><strong>B.G. 3-18</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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## METHODS OF COURSE EVALUATION 1979-80

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<td>PRE-CLINICAL COURSES</td>
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<td>9. DENTAL MATERIALS</td>
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<td>10. RESTORATIVE</td>
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### NOTES

1. All results will be reported as A/B/C/F in subjects 1 to 8, and Hon/Pass/Fail in subjects 9 and 10.

2. Supplemental examinations will be available in subjects 1 to 8 and supplemental pre-clinical practice and exam in 9 and 10.

3. Term work in Community Dentistry will count towards Second Year grades in that subject.

4. Term work in General Nutrition will be based on a term test given at the end of the course.

September, 1979
<table>
<thead>
<tr>
<th>TOOTH &amp; SURFACE</th>
<th>INSTRUCTOR INITIALS</th>
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<tbody>
<tr>
<td>2 x Plaster</td>
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<td>1 x Plaster</td>
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<td>Preparation</td>
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<td>Pulp Protection</td>
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<td>Restoration</td>
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**Class I**
- 46B
- 36B
- 460
- 360
- 460L*

**Class V**
- 47BC
- 37BC
- 35BC*

**AMALGAM**
- 47MO
- 37MO
- 36DO*
- 45MOD*
- 47DO*

**Class III**
- 43D
- 33D*, 43D*

**CAST GOLD**
- INLAY
  - 44DO*
  - 35DO*
- INLAY-ONLAY
  - 45MOD
  - 45MOD

**Class III**
- 43M
- 33M
- 32D
- 41M.(L.A.)*

**RESIN**
- Class V
  - 41F
  - 31F, 32F.

*Option only

**NOTE:** Instructor's signature does not necessarily indicate that the work done has been.
UNIVERSITY OF TORONTO
Faculty of Dentistry
DEPARTMENT OF RESTORATIVE DENTISTRY
First Year - 1979-80

TEST #4 (Practical) is to be completed in the allotted time of two hours (2.0) and consists of the following three parts:

PART I
(Value 13)

On a selected ivorine tooth, with the typodont mounted in the manikin head, execute a cavity preparation for restoration in composite resin.

The cavity preparation is located on the mandibular right cuspid (4.3) facial surface and should exhibit the following characteristic features and dimensions:

1. The cavity outline is centred on the facial surface mesio-distally.
2. The gingival wall is 1.0 mm. supragingival.
3. The outline form is a conventional kidney-shape as described in lectures:
   (i) extending from the mesial wall to the distal wall a distance of 5.0 mm.
   (ii) extending from the gingival wall to the occlusal wall a distance of 2.0 mm.
4. The axial wall is curved mesio-distally
5. The cavity depth axially at the gingival wall is 1.25 mm.
6. The cavity depth axially at the occlusal wall is 1.5 mm.
7. The cavity preparation walls are shaped along the mean direction of enamel cleavage.
8. The retention form is adequate and located properly.
There is no need for the removal of remaining caries.

There is no need for convenience form.

The enamel walls are prepared for the acid-etch technique.

The cavity is clean of any debris.

**PART II**

**Value 4**

Select the proper pulp protection agent and apply as required to the cavity preparation in Part I.

**PART III**

**Value 8**

On a selected 2 x natural size plaster tooth prepare a conservative mesio-occlusal cavity preparation for restoration with silver amalgam.

The tooth selected is the mandibular right second bicuspid (4.5) and the cavity preparation should exhibit the following dimensions and characteristic features:

(Dimensions given are natural size - convert by multiplying by two).

1. The occlusal cavity depth measured from either the mesial or distal pit to the pulpal floor is 2.0 mm.
2. The gingival seat is located 1.0 mm occlusal to the cemento-enamel junction.
3. The gingival seat width, axially is 1.25 mm
4. The outline form:

   (i) accommodates a 1.0 mm diameter round-ended condenser at its
3.

**TEST # 4 continued ...**

narrowest point.

(ii) requires the removal of the entire central developmental groove because of caries. The caries however has no lateral spread in the dentin on either side of the groove.

(iii) requires the removal of the mesial marginal groove because it is poorly coalesced.

(iv) requires that the occlusal cavo-surface outline terminates on inclined planes to assure self-cleansing areas.

(v) includes accessory fissures radiating from the distal pit, with the exception of their terminal .5 mm.

(vi) requires that the proximal facial and proximal lingual outlines located in self-cleansing areas.

5. The lingual groove is well coalesced.

**TOTAL VALUE: 25**

**TOTAL TIME: 2.0 HOURS.**
CAVITY PREPARATION FOR AMALGAM

FAILURE due to:
(1) Depth - excessive insufficient
(2) Gross Outline - Over-extension (+ 1 m.m.) Under-extension (Bulk)
(3) Inadequate resistance form (Margin)
(4) Incomplete

PASS (LOW) due to:
(1) Dimensions markedly greater or less than ideal
(2) Execution rough
(3) Retention less or greater than ideal

PASS (HIGH) due to:
(1) ONLY three features require minor improvement
(2) Ideal

RUBBER DAM

FAILURE due to:
(1) Lack of safety floss
(2) Technique providing inadequate isolation

PASS (LOW) due to:
(1) Clamp selection ) application) Less than ideal stability )

PASS (HIGH) due to:
(1) Ideal application
2.

PULP PROTECTION

FAILURE due to:
(1) Improper choice of materials
(2) Incorrect application
(3) Presence of cement on margin - Contributing to marginal leakage
(4) Incomplete

PASS (LOW) due to:
Less than ideal application but acceptable

PASS (HIGH) due to:
Ideal

MATRIX APPLICATION

FAILURE due to:
(1) Lack of rigidity
(2) Lack of confinement
(3) Lack of contact provision
(4) Lack of wedging

PASS (LOW) due to:
(1) Acceptable but less than ideal in more than two above listed criteria

PASS (HIGH) if other criteria met except:
(1) Occlusal of band 1 m.m. occlusal to contemplated marginal ridge
(2) No compound used
(3) Ideal
3.

AMALGAM RESTORATION

FAILURE due to:

(1) Unacceptable voids or pitting leading to failure

(2) Unacceptable overhang detectable with floss

(3) Lack of marginal integrity (ditching)

(4) Gross over-contour under)

PASS (LOW) due to:

(1) Less than ideal consistency

(2) Presence of minor over-contour (Correctable flash or overhang)

PASS (HIGH) due to:

(1) Degree of carving and burnishing

CAVITY PREPARATION FOR A CAST GOLD INLAY OR ONLAY

FAILURE due to:

(1) Lack of draw (undercut)

(2) Absence of bevel

(3) Depth excessive insufficient

(4) Inadequate resistance form - bulk

(5) Incomplete margin

PASS (LOW) due to:

(1) More than 10° of convergence (700 Tapered Fissure Bur)

(2) Less than ideal finish line

(3) Rough execution

PASS (HIGH) due to:

(1) Degree approaching ideal
**SAMPLE MARKING GUIDE**

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