

**THE DETERMINATION OF PREDICTIVE CRITERIA
FOR THE PLACEMENT OF ADULT STUDENTS
IN CHEMISTRY 020
AT THE LETHBRIDGE COMMUNITY COLLEGE**

NORRIE FULLER

B.Ed., University of Lethbridge, 1977

A One-Credit Project
Submitted to the Faculty of Education
of The University of Lethbridge
in Partial Fulfillment of the
Requirements for the Degree

MASTER OF EDUCATION

LETHBRIDGE, ALBERTA

April, 1996

Dedicated to

Ken, Craig and Amanda

TABLE OF CONTENTS

INTRODUCTION	1
PURPOSE OF THE STUDY	3
BACKGROUND TO THE STUDY	5
The Assessment and Placement Process	5
Chemistry 020	6
THE LITERATURE	8
METHODOLOGY	16
Sample Groups	16
Data Collection	16
ANALYSIS OF DATA	18
RESULTS	19
College and University Preparatory Program	
Students	21
General Studies Program Students	24
DISCUSSION	28
CONCLUSION	31

REFERENCES	33
APPENDIX 1	35
APPENDIX 2	36

LIST OF TABLES

Table 1: Summary of Student Sample Groups	21
Table 2: Variables: College and University Preparatory Students	22
Table 3: Correlation Matrix for the College and University Preparatory Sample	23
Table 4: Variables: General Studies Students	25
Table 5: Correlation Matrix for the General Studies Sample	26

INTRODUCTION

Students entering the Programs of College and University Preparatory and General Studies at the Lethbridge Community College undergo an assessment process prior to placement into courses. The assessment and placement of students may be considered necessary as the individual students comprising these programs have diverse educational backgrounds. The ultimate goal of the assessment and placement process is to enhance student success.

Student success is inherently related to course completion. Successful course completion is a concern being addressed due to three primary factors.

Firstly, the Lethbridge Community College and Faculty of the Lethbridge Community College have a professional commitment to facilitate student success. A fundamental assumption in the facilitation of student success is that appropriate student placement will enhance successful course completion. Placement standards are thus continuously reviewed and modified.

Secondly, ensuring student success within educational institutions is becoming crucial as the Provincial Government moves toward the measurement of institutional accountability and effectiveness with “Key Performance Indicators.” Included as ‘Key Performance Indicators’ are successful course completion, successful program completion and student satisfaction.

Finally, students enrolled in the College and University Preparatory and the General Studies Programs at the Lethbridge Community College are diverse in that they display a wide range of academic and personal histories. These programs are, to a great extent, self directed and generally lead to further study. The formula now being utilized by the Student Finance Board for

student funding includes successful course completion. A student that does not successfully complete courses in which they are enrolled may have their funding compromised.

Prerequisites on transcripts may not ensure that the adult learner has the knowledge required for the next academic course. For example, an adult student may have successfully completed Chemistry 10. However, if the final mark was below 65% and the course was taken 10 years prior, the student may not have the prerequisite knowledge required to successfully complete Chemistry 020. This is compounded by the fact that the College and University Preparatory Programs have fewer instructional contact hours than the High School Courses. Hence, there is less classroom time for review and the course work is accelerated. Additionally, adult students can be overwhelmed by family situations, financial pressures, employment, etc.

The importance of correct student placement becomes obvious, for if not appropriately placed, students may become frustrated and consequently be unsuccessful in their educational pursuits. Due to funding restrictions, students that do not pass the courses in which they are enrolled are usually not able to repeat them. An additional consequence for unsuccessful course completion may be the loss of funding for further educational endeavors.

Appropriate placement of adult students in courses, therefore, is essential for their educational success and the success of the educational institution in which they are enrolled.

PURPOSE OF THE STUDY

The placement of students in Chemistry 020 at the Lethbridge Community College is the result of a multifaceted, holistic assessment process. The assessment process includes placement test scores (Canadian Achievement Tests and Computerized Placement Tests) and the expertise of the Assessment Office. It has been recognized by the Assessment Office and myself, the Instructor of Chemistry 020, that factors other than placement test scores have a profound impact upon the successful completion of Chemistry 020. The age of the student, the presence of future educational goals, the attitude and the motivation of the adult student have a definite bearing upon success and course completion.

The literature indicates that the prediction of success in an academic area is difficult to do with absolute certainty. The determination of the presence of the academic skills required for successful course completion does not guarantee that a student will successfully complete a course. As stated by O'Shea (1994) "there is a gulf between having the ability to perform and actually performing, as we all know too well" (p.4).

The relationship between the final mark in Chemistry 020 and the results of the subtests included within the Canadian Achievement Tests and the Computerized Placement Tests are examined in this study. Additionally, the relationship between the final grade in Chemistry 020 and identifiable noncognitive factors are explored. These noncognitive factors include the age, the gender, the last grade completed and the presence of a future educational goal.

The purpose of this study is to examine predictive criteria that will facilitate appropriate placement decisions for students entering Chemistry 020 at the Lethbridge Community College.

An exploration of the backgrounds and the specific skills of students that have previously taken Chemistry 020 at the Lethbridge Community College might reveal criteria that can be utilized in the refinement of the placement process. The determination of predictive factors, their relative ordering and weighting would help to ensure student preparedness prior to entering Chemistry 020. This would be beneficial to the individual students, the class, the instructor and the institution.

BACKGROUND TO THE STUDY

The Assessment and Placement Process

Students that apply for entrance to the programs of College and University Preparatory Studies and General Studies at the Lethbridge Community College are commonly students that aspire to further educational endeavors. College and University Preparatory and General Studies provide a means through which students are able to obtain prerequisites, entrance requirements or educational experience prior to moving toward further educational goals. In other words, the programs are often transitional.

The educational backgrounds of adult students entering the above programs are diverse and their future educational goals are varied. Therefore, each student essentially requires an educational program designed to meet specific individual needs and goals. This design must begin with an assessment of the skills, backgrounds and educational proficiencies that each adult student possesses.

Students that apply to enter the College and University Preparatory Program provide information concerning personal data, educational background and future aspirations. Students then write Form A of the Canadian Achievement Tests (CAT) which consist of four subtests that include Reading Vocabulary, Reading Comprehension, Mathematics Computation and Mathematics Concepts and Applications. These subtests are further described in Appendix 1.

Students that apply to enter the General Studies Program also provide information concerning personal data, educational background and future aspirations. These students then write Computerized Placement Tests (CPT) prepared by The College Entrance Examination

Board and Educational Testing Services. The primary function of these tests, as described by the Computerized Placement Test developers in the Technical Data Supplement (1993) "is to determine which course placements are most appropriate for students and whether or not remedial work is needed" (p. 1). Students complete four subtests consisting of Reading Comprehension, Sentence Skills, Arithmetic, and Elementary Algebra. These subtests are further described in Appendix 2.

Based upon the information obtained through the application process and the Assessment Center, a program is devised that will allow a student to successfully fulfil their educational needs.

Chemistry 020

The Chemistry course described below was the course taken by the student sample that has been analyzed in this study.

Chemistry 020 is a course offered at the Lethbridge Community College through the Division of Continuing Studies in the University and College Preparatory Program. It is an introduction to basic chemical principles. Prerequisites for the course include Chemistry 10 or Science 10 (from High School) or Science 010 (from the Lethbridge Community College) or an acceptable equivalent. The course involves the study of the fundamentals of organic and inorganic chemistry. Theory and laboratory work emphasize the methodology of scientific problem solving and the scientific method. The course has evolved and been developed specifically for the adult learner.

The course being examined in this study, was sixteen weeks in duration and required

seven hours of classroom time per week. Five hours were spent in theory class and two hours in the laboratory.

Evaluation for the course included weekly laboratory write-ups that were graded for accuracy on the basis of qualitative and quantitative results. Theory exams and a comprehensive final exam were also course requirements.

The students utilized a textbook designed for the adult learner. A laboratory manual was utilized by each student. The experiments conducted in the lab session paralleled the theory classes and were utilized in developing or demonstrating concepts in theory. A self directed study guide was also provided which enabled the student to practice and monitor his/her own progress.

All of the materials listed above were constantly being modified and revised. Modifications occurred on a yearly basis with the primary input for alterations being the students. All but the textbook have been developed, written and edited by the author.

Support services were available to all students in Chemistry 020. These included counselling, peer tutoring, instructor tutoring and remedial intervention.

THE LITERATURE

It is generally recognized that the prediction of grades in Chemistry is a complex process. However, through the examination of factors that are characteristic and common in students that have successfully completed Chemistry, it may be possible to better place students in Chemistry classes. Better placement should result in increased student success, with greater rates of course completion.

Nordstrom (1989) recognized that the poor achievement of first year engineering students in chemistry courses "signals the need for the identification of criteria that will result in correct placement decisions for incoming college students" (p.3). Ewing (1986) was also concerned about the poor performance of students in Chemistry. The intent of Ewing's (1986) study was to help advisors and students make choices as to whether or not students should even register in Chemistry.

Chemistry is considered an applied science. In order to complete a Chemistry course successfully, a student must enter the course with basic prerequisite skills. Without adequate foundations in mathematics, it would be impossible for a student to solve and interpret Chemistry problems. House (1993) in his work with first year students enrolled in introductory Chemistry stated that "results suggest that there is a set of minimum mathematical skills necessary for passing introductory chemistry" (p.23). A study conducted by Sollimo (1988) involved an examination of academic records and the unsuccessful completion of an introductory college level Chemistry course. Sollimo stated that "while prior math level did not correlate highly with success in Chemistry, ninety one (91) percent of the students in the A and B grade

category had math levels at or above the course math pre-requisites. Fifty-nine (59) percent of the students who failed or dropped the course had a math level lower than the course pre-requisites" (p.11).

Ewing (1986) found that the American College Testing (ACT) Math score was a good indicator of success in introductory Chemistry. Additionally, a minimum Scholastic Aptitude Test (SAT) Math score is identified and seen as a signal of a high risk chemistry student. Nordstrom (1989) found the "SAT/ACT mathematics test score to be the most important predictor of grade in college chemistry" (p.11).

However, the findings of Hurov (1987) provided an alternative point of view. The intent of this study was to identify the prerequisite skills that best correlated with successful completion of Fundamentals in Chemistry at the Saint Louis Community College. The skill levels of students in reading, computational skills and critical thinking ability were assessed using the Nelson-Denny Reading Test (NDRT), the Numerical Reasoning subtest of the Differential Aptitude Test (DAT), and the Watson-Glaser Critical Thinking Appraisal (WGCTA). Hurov's (1987) findings indicated that there is a "moderate relationship" (p.2) between the Nelson-Denny Reading scores and course success ($R=0.30$), a weaker relationship between the Watson-Glaser Appraisal of Critical Thinking and course success ($R=0.25$), and the lowest correlation ($R=0.19$) was between successful course completion and the Differential Aptitude Test of Numerical Reasoning. Hurov's interpretation of the degree of the relationship between test scores and course success is countered by Hietala (1994). Hietala stated "Coefficients of linear correlation may be as low as 0.30, which would mean that less than 10% of the variation in end of semester results can be accounted for on the basis of pretest scores. The relevant measure is the value of

R-squared which is 0.09 when $R=0.30$." (p.3). The numeric relationship given by Hietala provides a means of discerning what Hurov interprets as a "moderate relationship".

Hurov (1987) also found a minimum reading score which was indicative of unsuccessful grades in Fundamentals of Chemistry. A reading score below the 20th percentile on the Nelson-Denny Reading test was highly related to failure. A minimum math score was not related to unsuccessful course completion. Rather, Hurov (1987) found that "some students that did not do well on the math test did extremely well in the course" (p.7).

Additionally, Ewing (1986) found "that the English ACT Score is possibly a little better for predicting Chemistry 101 grades than was the Math score" (p.8). Nordstrom (1989) reported that the grade obtained in high school English was a factor in predicting the performance of students in chemistry (p.10).

Sanchez and Betkouski (1986) identified characteristics that were common to successful students in general college chemistry. The students described as successful were older, had a better grasp of science process skills and had good algebra grades.

House (1993) investigated the relationship between noncognitive predictors of student success and subsequent achievement in introductory college chemistry. He also recognized that before considering any noncognitive factors, the presence of minimum mathematical skills was necessary for successful course completion.

Sollimo (1988) recognized the importance of both reading and mathematical ability with respect to successful completion of Chemistry courses; "In college chemistry, students typically find major difficulties due to the demands of reading comprehension and quantitative skills associated with an abstract discipline." (p.3).

Therefore, it would seem reasonable to conclude that correct placement of students in Chemistry would require a minimum level of preparedness in both mathematics and reading. The absence of prerequisite math and reading skills is identified as being related to unsuccessful course completion in Chemistry.

The literature generally recognized that appropriate testing in math and reading are assessment tools that would be helpful for student placement in Chemistry courses. The determination of minimum math and reading scores would be beneficial to ensure proper advisement of students.

Further, there was acknowledgment within the literature of the tendency of some students to underperform and others to overperform based upon the predictive placement testing. The fact that students possessing the necessary prerequisite skills for Chemistry do not succeed as well as expected and that students that do not have strong prerequisite skills sometimes complete Chemistry with grades that are beyond those that are anticipated has been investigated by researchers.

To address the question of overperformance and underperformance of these students, noncognitive factors need to be considered. The presence of definite goals, support of the learners outside the educational institution, age, gender and the learners' attitudes toward their own abilities may also be relevant considerations that require attention when attempting to predict student success in Chemistry courses.

Sollimo (1988) surveyed students that were unsuccessful in General Chemistry. Student responses indicated that the most difficult part of Chemistry 105 was the time pressure related to completing assignments and preparing for exams. This was followed in order by taking notes,

the chemical concepts, the mathematics in the course and reading the text. The responses from the unsuccessful students would appear to reflect the importance of non-academic skills such as organization, maturity, persistence, and time management.

Manning (1992) found that factors other than high school grade point average and scores on the ACT need to be considered when predicting student success. The social orientation of a student, age and student goals at the time of enrolment are also relevant factors that required attention when placing students for successful course completion. Manning (1992) recognized that nonacademic factors related to the prediction of success were difficult to quantify and required further study.

Nordstrom (1989) utilized solely academic predictors in his study with engineering students in freshman Chemistry. He utilized discriminant analysis to group students into two categories: those that received final grades of A, B, or C and those that received grades of D, F or W. When reviewing the records of students that were not classified correctly, the following explanation was given:

"Among students whose performance was lower than had been predicted, it was found that almost all of them had received "D's," with only a few "W's" and almost no "F's." This pattern suggests that they really did have the ability to be successful if they had only worked a little harder. Among students whose performance was higher than had been predicted, almost all the grades were "C's," suggesting that these students managed to put forth the additional effort needed to be successful. Few of these students earned higher than a "C". Those students who did receive a higher grade tended to have been older than traditional freshmen and to have transferred credit from other institutions." (p.10).

The statements by Nordstrom (1989) again suggest that student success is also related to non-academic factors. The explanations for the incorrect classifications of the students in this study however, seem to be somewhat simplistic and may require further analysis. The specific

reasons for underachievement should be examined further. Perhaps underachievement is related to inadequate time for study due to employment, family obligations or a multitude of other factors as indicated by Sollimo (1988).

To address non-academic factors in predicting success in an introductory Chemistry course, House (1993) studied the relationships between achievement in the Chemistry course and initial student attitudes, admission test scores, and years of high school math taken. The sample group included 179 new freshman students, 76 were male and 103 were female students. The mean age of these students was 18.11 years, Standard Deviation = 0.32. Prior to the commencement of classes, students completed a questionnaire that measured their self-ratings of their academic abilities (overall academic ability, drive to achieve, mathematical ability, and self confidence in intellectual ability) and their expectations for academic achievement (expectation of earning at least a B average in college and expectations of graduating with honors).

The results of House's (1993) study indicated that "the students' initial attitudes are significant predictors for their subsequent grade achievement in introductory college chemistry" (p.21), and that "students' attitudes were better predictors of grade achievement in chemistry than ACT Composite scores" (p.21).

Recognition of the limitations in predicting performance in Chemistry solely through assessment test scores and prior academic histories was discussed by Sollimo (1988), Manning (1992), Nordstrom (1989) and House (1993). It was apparent that prediction of successful course completion in chemistry should, where possible, include cognitive (academic) components and noncognitive (non-academic) components.

The literature examining both cognitive and noncognitive aspects of predicting

achievement in college chemistry is limited in number. House (1993) agreed with this assessment: "Several previous studies have examined either cognitive measures or student attitudes as predictors of chemistry achievement but few studies have evaluated the contributions of both types of variables toward the explanation of grade performance in college chemistry" (p.5).

To illustrate further the limitations of using only achievement test and prior academic histories in the placement of students, it is helpful to look outside the subject area of Chemistry. In a study conducted by Wolfe and Johnson (1995) utilizing the GPA of 201 psychology students, the importance of the inclusion of non-academic and noncognitive factors was illustrated. They examined personality as a predictor of college performance. Their findings showed that the average grade earned in high school accounted for 19% of the variance in the GPA of the sample. The personality characteristic of "self control" accounted for 9% of the variation while the SAT score accounted for 5% of the variation. Further "for the purpose of predicting GPA, it does not matter how self-control is defined or measured. Organization, control, conscientiousness, and self-efficacy all appear to do roughly the same kind of explanatory work and account for roughly equal portions of the GPA variance." (p.183).

Goleman (1995) theorized that the most important predictor of success was not intelligence as measured by standardized IQ and achievement tests but rather self-awareness and self-control.

A further limitation is the lack of information dealing with adult learners. The literature reviewed was based primarily upon freshman student samples. The majority of these students had not been out of high school for more than three years prior to entering college and

subsequently college chemistry. The exception to the above is the study performed by Janet Hurov (1987). Students sampled in this study were primarily white females with a mean age of 27.5 years.

House (1993) identified the inclusion of only traditional-aged college students to be a limitation of the results of his study. He further identified the need to "determine if these findings would also be noted for adult learners" (p.22).

An examination of the relationship between achievement in Chemistry 020, placement testing scores and nonacademic factors such as age, gender, the last formal high school grade completed and the presence of a definite educational goal will perhaps be helpful in improving placement decisions.

METHODOLOGY

Sample Groups

The sample was comprised of students that had taken Chemistry 020, instructed by the author, at the Lethbridge Community College from 1989 through 1995. Classes were a combination of students from the College and University Preparatory Program and the General Studies Program.

Records were obtained for 464 students. Students that repeated Chemistry 020 were included in the sample for their first attempt at the course.

As the intent of this study was to examine the assessment and placement of students in Chemistry 020, only students that enrolled in Chemistry 020 immediately following the assessment and placement process were included in the sample groups.

Students that met the criteria above were further subdivided into two distinct and discrete groups. The first group was composed of students in The College and University Preparatory Program that wrote the CAT Tests. The second group was composed of students in the General Studies Program that wrote the CPT Tests.

Data Collection

The data were obtained by utilizing mark books, attendance records, general information sheets, Assessment Center records for CAT or CPT test results, and complete student files as maintained by the Registrar's Office in Student Services at the Lethbridge Community College.

The data obtained are described below:

1. Final Mark – The final mark obtained in Chemistry 020. The mark is a composite score based upon:

14 Laboratory Assignments and Results	25%
5 Theory Exams	45%
Cumulative Final Examination	30%
2. Age – A student's age in years when enrolled in Chemistry 020
3. Gender
4. Attendance – This was utilized to determine if a student completed the course, ceased to attend the class but did not withdraw (disappeared), or withdrew.
5. Goal – The future educational goal of the student. The goals included environmental science, nursing, university, technical programs, other college programs, undecided, and not stated.
6. Grade – The most recent grade completed by the student as disclosed upon the application for admission to the Lethbridge Community College.
7. Assessment Test – These results included the specific test written, subtest scores and the date the test was written. The CAT subtests were recorded as scale scores, whereas the CPT subtests were recorded as percentiles.

ANALYSIS OF DATA

Data was analyzed utilizing SPSS for Windows 6.0 (Student Version). The analysis outlined below was repeated for each of the student groups: students in the College and University Preparatory Program that wrote the CAT Tests were analyzed separately from students in the General Studies Program that wrote the CPT Tests.

Initially, descriptive statistics for each variable were determined. Secondly, Pearson correlation coefficients (R) were computed to examine the relationship between the final mark obtained in Chemistry and the predictor variables. Thirdly, Pearson correlation coefficients were determined between each of the predictor variables.

Finally, stepwise multiple-regression analysis was performed in order to generate a prediction equation for the final mark.

RESULTS

A total of 464 students were enrolled in Chemistry 020 between 1989 and 1995. Of this total number of students, 271 or 58.4% were not directly placed in Chemistry 020 after the assessment process. A total of 318 students in College and University Preparatory were assessed, 124 or 39% of these students were placed directly into Chemistry 020. In contrast, of the 120 students in General Studies, 69 students or 58% were placed in Chemistry 020.

A comparison on the basis of the variables shown in Table 1, shows distinct differences between the sample groups utilized in this study. This provided evidence to support the separation of the student sample into two distinct groupings based upon their Program of study.

The final mark was determined utilizing only students that completed the course. The mean final mark for all students that have taken Chemistry 020 was 71.0%. This is reasonably close to the mean final mark obtained by the students placed in Chemistry from General Studies at 71.2%. However, the mean final mark obtained by the student sample in College and University Preparatory was considerably higher at 76.3%.

Age differences were also apparent. The average age of students in College and University Preparatory was 2.9 years greater than that for students in the General Studies student group. This would also indicate that students in the College and University Preparatory group would have an increased time frame between their secondary school experience and their post secondary experience compared to the students from the General Studies group.

Gender differences exist. 58.1% of the students in College and University Preparatory were female whereas 40.6% of the students in General Studies were women.

The last grade of formal education completed also revealed distinctions between the sample groups. 75.4% of the General Studies students indicated that they had completed Grade 12, whereas only 54.0% of the students in College and University Preparatory completed Grade 12. If Grades 11 and 12 are considered simultaneously, 86.3% of the University and College Preparatory students had completed Grade 11 or 12 while 89.9% of the General Studies group had completed Grade 11 or 12.

The vast majority of students in both student groups possessed definite future educational goals: 91.9% of the College and University Preparatory students and 92.8% of the General Studies students had defined educational goals.

Table 1. Summary Statistics of Student Sample Groups.

	Total (N=464)	College and University Preparatory Students (N=124)	General Studies Students (N=69)
Final Mark* (mean)	71.0 SD=16.3 (N=364)	76.3 SD=14.6 (N=104)	71.2 SD=15.1 (N=55)
Age (Mean in Years)	24.9 SD=6.0	24.8 SD=6.0	21.9 SD=4.6
Gender (%)			
Female	55.4	58.1	40.6
Male	44.6	41.9	59.4
Course Completion			
Completed (%)	78.4	84.7	84.1
Withdrawal (%)	10.1	6.5	1.4
Disappeared (%)	11.4	8.9	14.5
Last Grade Completed (%)			
7	0.2		
8	1.9	0.8	
9	6.7	1.6	
10	16.6	10.5	7.2
11	19.8	32.3	14.5
12	52.4	54.0	75.4
Educational Goal (%)			
University	27.8	32.3	29.0
Environmental Science	11.9	13.7	21.7
Nursing	25.9	30.6	23.2
Other College Program	13.4	5.6	10.1
Technical Program	5.0	4.0	2.9
Alternative	8.4	5.6	5.8
Not Stated	3.2	1.6	4.3
Undecided	4.5	6.5	2.9

* only includes students that have completed Chemistry 020

College and University Preparatory Program Students

The following results apply to students that were in the College and University Preparatory Program, These students enrolled in Chemistry 020 immediately following the

assessment process and completed the course. Completion of the course was defined as students that attended the class on a regular basis, completed assignments and wrote the final examination.

Table 2 provides an overview of the variables considered for the sample group described above.

Table 2. Variables Selected for the College and University Preparatory Sample (N=104).

Variable	Value
Final Mark (mean)	76.3 SD=14.6
Age (mean)	24.8 SD=6.0
Future Goal	
Presence of a Future Goal (%)	91.9
Absence of a Future Goal (%)	8.1
Gender	
Female (%)	58.1
Male (%)	41.9
Last Grade Completed (mean)	11.462 SD=0.736
CAT Reading Comprehension Scale Score (CATCOMP) (mean)	673.423 SD=85.546
CAT Reading Vocabulary Scale Score (CATVOCAB) (mean)	703.240 SD=84.673
CAT Math Concepts and Application Scale Score (CATMATCON) (mean)	632.077 SD=75.881
CAT Math Computational Scale Score (CATCOMPU) (mean)	601.269 SD=83.913

The CAT Subtest with the highest mean was the Reading Vocabulary Scale Score followed by the Reading Comprehension Scale Score. The lowest score was the CAT Math Computational Scale Scores. The CAT Subtests showed that the scale scores obtained in the reading skill levels were higher than those obtained in the mathematical skill areas.

In order to gain an understanding of the relationship between the variables described

above and the final mark obtained by students in Chemistry 020, it is necessary to examine the Pearson correlation (R) of each variable with respect to the final mark obtained. In order to accomplish this, a correlation matrix was generated. This is shown as Table 3.

Table 3. Correlation Matrix for the College and University Preparatory Sample.
(Note: the abbreviations utilized are defined in Table 2)

	Mark	Age	CAT Comp	CAT Compu	CAT Macon	CAT Vocab	Future	Gender	Grade
Mark	1.000								
Age	0.398	1.000							
CatComp	0.253	0.272	1.000						
CAT Compu	0.314	0.026	0.113	1.000					
Cat Macon	0.220	-0.075	0.229	0.668	1.000				
Cat Vocab	0.265	0.460	0.752	0.111	0.201	1.000			
Future	-0.146	-0.050	0.134	0.030	-0.029	0.053	1.000		
Gender	0.015	0.077	0.139	0.271	0.363	0.164	-0.148	1.000	
Grade	0.063	-0.077	-0.163	0.020	0.092	-0.231	-0.012	0.004	1.000

Age was found to be the predictor variable with the highest correlation coefficient, 0.398, when final mark was the dependent variable. Therefore, based upon R-squared, 15.8% of the variation in the final mark for Chemistry 020 can be attributed to the age of the student. This was followed by the CAT Math Computational Scale Score, $R = 0.314$. The CAT subtest for Reading Vocabulary ($R = 0.265$) was closely followed by the CAT Reading Comprehension Scale Score ($R = 0.253$). The CAT Math Concepts and Applications subtest could account for 4.8% of the variation in the final mark of Chemistry 020.

There was a minimal relationship between the remaining independent variables and the

final marks for Chemistry 020: the presence of a definite future goal, (a dummy-coded variable, with $R = -0.046$) the last grade completed by a student ($R = 0.063$) and finally the gender of the student, also dummy-coded ($R = 0.015$).

A regression equation was generated in a stepwise fashion and included only two variables: Age and the CAT Math Computation Scale Score. In the following regression equation, the multiple-R was found to equal 0.501 with an R-squared value of 0.251.

$$\text{FINAL MARK} = 20.62 + 0.9570 * \text{AGE} + 0.05314 * \text{CAT Math Computation Scale Score}$$

This regression equation is significant, $F(2,101) = 16.938$, $p < 0.0001$.

Based upon the regression equation above, 25.1% of the variation in the final mark of students in Chemistry 020 can be accounted for by the variables of age and the CAT Math Computation Scale Score. The variation due to the independent variable Age alone is 15.8% and that due solely to the CAT Math Computation Scale Score is 9.9%.

General Studies Program Students

The following results apply to students from the General Studies Program that enrolled in Chemistry 020 immediately following the assessment process. All of the students included in this grouping regularly attended class, completed assignments and wrote the comprehensive final examination.

Table 4 provides a summary of the dependent and predictor variables considered for the sample group described.

Table 4. Variables Selected for the General Studies Sample (N = 55).

Variable	Value
Final Mark (mean)	71.2 SD=15.1
Age (mean)	21.9 SD=4.6
Future Goal Presence of a Future Goal (%) Absence of a Future Goal (%)	91.4 8.6
Gender Female (%) Male (%)	40.6 59.4
Last Grade Completed (mean)	11.745 SD=0.552
CPT Algebra Percentile Score (CPTALGEB) (mean)	61.964 SD=24.595
CPT Arithmetic Percentile Score (CPTARITH) (mean)	62.200 SD=22.411
CPT Reading Comprehension Percentile Score (CPTCOMPR) (mean)	65.345 SD=23.007
CPT Sentence Skills Percentile Score (CPTSS) (mean)	57.782 SD=25.580

The CPT subtest with the highest results was Reading Comprehension. It was closely followed by the Arithmetic Subtest and the Algebra Subtest. The Sentence Skills Subtest had the lowest score.

The following correlation matrix was generated to examine the relationship of the variables to the final mark.

Table 5. Correlation Matrix for the General Studies Sample.
(Note: Abbreviations utilized are defined in Table 4)

	Mark	Age	CPT Algeb	CPT Arith	CPT Compr	CPT SS	Future	Gender	Grade
Mark	1.000								
Age	0.094	1.000							
CPT Algeb	0.033	-0.162	1.000						
CPT Arith	0.124	0.084	0.538	1.000					
CPT Compr	0.121	0.082	0.128	0.217	1.000				
CPT SS	0.074	0.124	0.421	0.412	0.565	1.000			
Future	-0.373	-0.202	0.260	0.083	0.090	0.157	1.000		
Gender	-0.268	-0.175	0.022	0.010	-0.131	-0.044	-0.081	1.000	
Grade	-0.033	0.018	-0.040	0.099	0.041	0.033	-0.084	0.092	1.000

The predictor variable with the greatest correlation coefficient was the presence of a definite future goal. This variable had a Pearson correlation coefficient of -0.373. Therefore, utilizing R-squared, the presence of a definite future goal could be used as a predicting variable that accounts for 13.9% of the final mark variation. This was followed by gender with a correlation coefficient of -0.268. Both of these variables have been dummy-coded.

With respect to the CPT subtests, the Arithmetic percentile score had the highest correlation with $R = 0.124$. This was closely followed by the Reading Comprehension percentile score with $R = 0.121$. The Sentence Skills percentile score had a correlation of 0.074 and the Algebra percentile score had a correlation of 0.033.

The Pearson correlation for the independent variable of Age was 0.094. This would indicate that based upon R-squared, age could account for 0.88% of the variation in the final

mark for this sample group. This was in contrast to the College and University Preparatory sample where the correlation for the Age variable was 0.398 and accounted for 15.8% of the variation in the final mark.

A regression equation was computed in a stepwise fashion. The multiple-R was found to equal 0.478 with an R-squared value of 0.228. The regression equation follows:

$$\text{FINAL MARK} = 77.76 - 20.57 * \text{FUTURE GOAL} - 8.960 * \text{GENDER}$$

For this equation the future goal is dummy coded whereby 0 represents the presence of a future goal and 1 represents the absence of a future goal. Gender is dummy coded as 0 for females and 1 for males. This regression equation is significant, $F(2,52) = 7.689$, $p < 0.0012$.

Based upon the regression equation above, 22.8% of the variation in the final mark of students in Chemistry 020 is due to the variables of Future Goal and Gender. The presence of a definite future goal accounts for 13.9% of this variation and the gender of the student accounts for 7.18% of the variation. No other variables examined contributed to the regression model.

DISCUSSION

The prediction of final grades is a complex process. Traditional models have provided limited results. The regression equations generated in this study can only account for 25.1% and 22.8% of the variation in the final marks in Chemistry 020 for College and University Preparatory students and General Studies students respectively.

Other researchers faced with similar results have moved toward logistic regression and discriminant function analysis models. These models separate students into distinct categorical groupings. This was seen in the works of House (1993), Nordstrom (1989), and Hietala (1994). Hietala (1994) stated that discriminant function analysis "has been used to construct the model which classifies students into two groups, rather than try to predict their final mathematics mark as done with conventional regression analysis." (p.40).

The determination of distinct categorical groupings was not feasible with the student sample utilized in this study. Chemistry 020 was often a transitional course that provided prerequisites for further educational goals. The final grade that translates into 'successful course completion' differed with the educational needs of each particular student. Therefore, it was not possible to find a final mark that would satisfactorily result in distinct categorical groupings.

The recognition of the need for a multivariable approach in predictive studies was typically encountered. Hietala (1994) stated that "a multivariable or composite model, based on a weighted sum of several predictor variables, is both more accurate and reliable than one based on pretest scores alone" (p. 42). Sollimo (1988) also maintained that "No single variable appears to be predictive enough to be used in general college chemistry at Burlington County College." (p.9).

The variables utilized in this study were limited in scope. Predictive variables included scores on mathematics and reading placement tests and demographic information such as age, gender, the last grade completed in secondary education, and future educational goal. However, this data did not contain measures of motivational or attitudinal variables.

The importance of nonacademic variables was acknowledged by House (1993): "The results of this study indicate that students' initial attitudes are significant predictors of their subsequent grade achievement in introductory college chemistry." (p.21).

The separation of the students utilized in this study into two distinct samples has provided insights into non-academic variables that may be influential in the assessment and placement process for Chemistry 020.

Students from the University and College Preparatory Program and students from the General Studies Program were combined in the Chemistry 020 classes. The course design, the course difficulty, the instructor, and the teaching approach utilized were consistent for the entire sample group. This was not the case in any of the other studies cited.

The regression equations generated were very different for each of the sample groups. For students in the College and University Preparatory Program the variables included in the regression equation are student Age and the CAT Computational Scale Score, whereas for students in the General Studies Program the regression equation utilized the presence of a Future Goal and Gender.

A comparison of the variables analyzed for the College and University Preparatory Sample and the General Studies samples shows that the two samples are distinct. The average final mark for the College and University Preparatory sample seems to be higher than that for General Studies sample. This does not seem reasonable considering the General Studies students were younger, had

been out of school for less time, had a higher proportion of male students and a greater proportion had completed Grade 12. Due to the factors listed above, it would be reasonable to expect the General Studies students to have the higher average final grade rather than the College and University Preparatory sample.

This would lead to the supposition that variables other than those examined in this study must have a substantial bearing upon the final grade for students. This would be in agreement with the findings of Manning (1992), Sanchez and Betkouski (1986), Nordstrom (1989), House (1993) and Sollimo (1988).

Hietala (1994) found a similar result in his work with college students in Ontario:

"The number of years since this last mathematics course was taken is of slight importance, appearing in 4 out of 11 models but never ranking above third place. When it does appear, it has a positive coefficient: the more time since the last math course, the greater the contribution to the composite score. It therefore appears to apply an upward correction to compensate for pretest scores which may be affected by lack of recall rather than ability." (p.41).

Sollimo (1988) indicated "The most highly correlated variables with success in general college chemistry were GPA and the success ratio. They may also be highly reflective of non-academic skills such as maturity and persistence." (p.10). Betkouski and Sanchez (1986) found that the successful students in introductory chemistry were "older". If motivational and attitudinal variables are influential in academic achievement, it would be feasible that these variables change as an individual matures. Affective variables may have been reflected in the "Age" of the student populations examined.

CONCLUSION

In this study, attributes of students that had enrolled in Chemistry 020 at the Lethbridge Community College were examined in order to determine predictive criteria that would facilitate the assessment and placement process. Students were divided into two groups based upon enrolment in either the College and University Preparatory Program or the General Studies Program. Data for each group were treated independently. The predictive factors examined included age, gender, grade last completed, the presence or absence of a definite future educational goal, and the results from either CAT tests (for College and University Preparatory students) or CPT tests (for General Studies students). It should be recognized that students included in this study had undergone the assessment and placement process at the Lethbridge Community College.

The results of the regression equations determined are of limited benefit for the reliable placement of students in Chemistry 020. A modest relationship was found between the final mark and the CAT Math Computational Scale Score. The relationships between the final mark in Chemistry 020 and the remaining CAT and CPT subtests were weak. Thus, minimum subtest scores required for success in Chemistry 020 were not determined. The relationships between the final grade and the identifiable noncognitive factors examined were modest. Therefore, the determination of reliable predictive criteria that could be utilized for the placement of students in Chemistry 020 was not obtained by this study. A limitation to this study was the relatively small sample size.

The roles of motivational and attitudinal predictive variables were not directly examined in this study. A new direction for future research would be to examine the influence of attitude and motivation on the achievement of adult students in Chemistry. The examination of attitude and motivation may also provide further insights into reasons that explain for some students, the incongruency between the ability to perform and performance.

The prediction of final grades is complex. A multitude of factors are involved in student performance and consequently their final mark in a particular course. The factors are multifaceted, and include academic and non-academic aspects. Those which are non-academic are the most difficult to measure but may provide the greatest insight into the prediction of successful course completion.

Distinct predictive models for adult and mature students may need to be developed. These students may not 'perform' well within academic models of placement that exclude motivation and attitude. Rather, these non-academic factors may be more influential in their academic success.

REFERENCES

- Canadian Test Centre (1983). Canadian Achievement Tests Class Management Guide Form A. CTC/McGraw-Hill Ryerson Ltd. Scarborough, Ontario.
- College Entrance Examination Board and Educational Testing Service (1993). Accuplacer Computerized Placement Tests Technical Data Supplement.
- Ewing, Gordon J. (1986). Predicting Grades in Chemistry 101. New Mexico State University. (Report No. SE 047 970). (ERIC Document Reproduction Service No. ED 281 776)
- Goleman, Daniel (1995). Emotional Intelligence. Bantam Books.
- Hietala, Paul W. (1994). A Multivariable Approach to Assessment in Mathematics for First Semester Programs in Technology at the Colleges of Applied Arts and Technology. Ontario Colleges Mathematics Association Skills Assessment Project Report.
- House, J. Daniel (1993). Noncognitive predictors of achievement in introductory college chemistry. Chicago, Ill.: Association for Institutional Research. (Report No. HE 026 683). (ERIC Document Reproduction Service No. ED 360 944)
- Hurov, Janet Torrisi. (1987). A study of the relationship between reading, computational, and critical thinking skills and academic success in Fundamentals of Chemistry. Florissant Valley, Mo.: Saint Louis Community College. (Report No. JC 870 451). (ERIC Document Reproduction Service No. ED 286 569)
- Manning, Wayne. (1992). Evaluation of the freshman class to determine predictors for academic success at Panhandle State University. Emergence of Higher Education in America Seminar. (Report No. HE 025 544). (ERIC Documentation Reproduction Service No. ED 345 649)

Nordstrom, Brian H. (1989). Predicting performance in freshman chemistry. Boston: National Meeting of the American Chemical Society. (Report No. SE 052 362). (ERIC Documentation Reproduction Service No. ED 347 065)

O'Shea, Judy. (1994). Assessment, Placement, and Performance of English 020 Students at Lethbridge Community College. A Project for the Partial Fulfilment of the Master of Education Degree. University of Lethbridge.

Sanchez, Karen & Betkouski, Marianne (1986). A study of factors affecting student performance in community college general chemistry courses. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (59th, San Francisco, CA, March 28-April 1, 1986). (ERIC Documentation Reproduction Service No. ED 275 549)

Sollimo, Vincent J. (1988). A retention study at Burlington College in general college chemistry. Pemberton, N.J.: Burlington County College. (Report No. JC 870 042). (ERIC Documentation Reproduction Service No. ED 295 687)

Wolfe, Raymond N. & Johnson, Scott D. (1995). Personality as a Predictor of College Performance. Educational and Psychological Measurement, Vol. 55 No. 2, April 1995. Sage Publications, Inc.

APPENDIX 1

Descriptions of the Canadian Achievement Subtests as described by the CTC/McGraw-Hill

Ryerson staff (1983):

1. **Reading Vocabulary-** Vocabulary development is essential for understanding concepts and comprehending verbal and written material. Vocabulary skills are measured in five general areas: same meaning, compound word meaning, affixed word meaning, opposite meaning, and multimeaning.
2. **Reading Comprehension-** Reading comprehension is essential in order to understand a reading passage. To understand a reading passage, one must be able to recognize and understand the words and sentences that make up that passage. Reading comprehension is divided into literal, interpretive and critical comprehension.
3. **Mathematics Computation-** Mathematical computational skills involve decision making concerning which mathematical operation to perform, if the answer obtained is reasonable and an interpretation of the results obtained. The test includes addition, subtraction, multiplication and division skills of whole numbers, fractions, decimals, integers, exponents, and algebraic expressions.
4. **Mathematics Concepts and Applications-** Mathematical concepts and applications include a sampling from a wide range of mathematical skills with an emphasis on concepts rather than isolated facts. The test includes numeration, number theory, number sentences, and number properties.

APPENDIX 2

Descriptions of the CPT Subtests as given by the Accuplacer Computerized Placement Tests Technical Data Supplement (1993).

1. Reading Comprehension- This test is composed of questions that include sentence relationships, reading passages and related questions, information processing requiring explicit statements related to the main idea, explicit statements related to the secondary idea, inference and application.
2. Sentence Skills- This test contains questions of two types: sentence correction and construction shift. Skills tested include complete sentence construction, relationships of coordination and subordination and the logic of the sentence.
3. Arithmetic Test- This test contains questions which involve operations with whole numbers and fractions, operations with decimals and percents, and applications and problem solving.
4. Elementary Algebra Test- This test is comprised of questions which involve operations with integers and rationals, operations with algebraic expressions and the solution of equations, inequalities and word problems.