2005

# Cognitive,personality and demographic attributes of student change.

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| 2003-2005 | Board of Directors (2003-2004); Advisory Board (2005)<br>National Association for Empowering Caregivers |

# COGNITIVE, PERSONALITY, AND DEMOGRAPHIC ATTRIBUTES OF STUDENT CHANGE

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A Dissertation

Presented to

The School of Graduate Studies

Department of Counseling

Indiana State University

Terre Haute, Indiana

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In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

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by

Jeanne Marie Henry

December 2005

SCHOOL OF GRADUATE STUDIES
INDIANA STATE UNIVERSITY
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## CERTIFICATE OF APPROVAL

## DOCTORAL DISSERTATION

This is to certify that the Doctoral Dissertation of

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entitled

Cognitive, Personality, and Demographic Attributes of Student Change

has been approved by the Examining Committee for the dissertation requirement for the

Doctor of Philosophy degree

in Guidance and Psychological Services (Counseling Psychology)

December 2005

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# ABSTRACT

This study was an examination as to whether cognitive, personality, and demographic attributes of students have changed over time. Archival data for 10 cohorts of freshman students from a private Midwest engineering institution were used. Data consisted of Myers-Briggs Type Indicator (MBTI) results, Learning Environment Preferences (LEP) results, and demographics. ANOVAs were performed for all interval data and Chi-Square analyses for all nominal data. Statistical significance was found for MBTI Thinking-Perceiving and Sensing-Intuition scales, LEP Cognitive Complexity Index scores, and demographic variables including age, parental education level, and SAT scores. Results are discussed in terms of practical significance, trends evidenced in results, implications for further research, and educational service provisions.

# ACKNOWLEDGMENTS

First of all, I would like to acknowledge Rose-Hulman Institute of Technology Office of Institutional Research, Planning, and Assessment for availing data for this research. My appreciation is extended to Gloria Rogers in particular for her assistance in assuring that data and resources were available that were essential to the formulation and completion of this research. Gloria Rogers and Gwen Lee-Thomas's original insights regarding student change inspired me to begin pursuing this research.

I would like to thank my committee for their support, feedback, and direction throughout this project. Matt, your input and feedback helped me to rethink rationales, content, and presentation. Gwen, your critiques, insights, and support have been invaluable. Will, thank you for pushing me beyond what I thought I could endure and putting up with my resistance, frustration, and errors along the way. I have learned more about learning, persistence, and character than there is space here to note.

I would also like to thank Michael Shuff for challenging me to improve while extending many kindnesses along the way. Your words have been at the root of numerous changes. Thank you for being an example of perseverance and personal strength. I would likewise like to thank Michele Boyer for always expecting excellence and teaching me that it is not only ok but wise to consult with others at times to achieve your best.

To Marian, Marty, Kate, and Melanie, your mentoring and gentle though direct guidance has anchored me time and time again throughout this project. Thank you for

helping me to believe this was possible and for showing me through example the integrity I needed to develop. To all of my friends and family, thank you for the confidence and persistence you helped to instill, for the enduring love you have shown, and for patiently waiting for me.

Finally, I want to thank my brother, Dennis, for first telling me that I would "write a dissertation someday and be a doctor." I have carried these words with me for over 26 years. Your life was and continues to be an inspiration to me. Over the past five years in particular, I have carried with me your humor, persistence, and words of wisdom. In my heart, you have continued to be there when I have needed you the most.

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# INTRODUCTION

The educational paradigm in the field of engineering science and technology has traditionally been content-driven though it has undergone significant and continuous change (Grayson, 1993). This change has been largely due to changes in student populations. Nearly three decades ago Cornish (1977) described a “tremendous” and “convulsive” change in society prompting educational change. Engineering education has progressively moved beyond a product-based curriculum to a more process-based curriculum.

One of the most recent and significant milestones in this engineering education paradigm change was the introduction of Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology 2000 accreditation standards (ABET EC 2000; Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 2000), which were initially proposed in 1995. These standards established outcome-based expectations for student learning in engineering and technology. The ABET EC 2000 criteria emphasized the results of the educational process, as opposed to an evaluation based primarily on curriculum design. The resulting increased focus on assessment and accountability has powered a shift from curriculum-based models that emphasize what is presented toward learning-based models that emphasize student-learning outcomes. The emerging measure of institutional excellence has become student-learning outcomes (Astin & Sax, 1998).

The outcome emphases and expectations of the ABET EC 2000 criteria as well as its inherent challenges remain equally evident in the 2004-2005 updated evaluation criteria for engineering institutions (Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 2003). Examining these challenges of meeting outcome-based standards through the lens of Astin's (1993) input-environment-outcome (I-E-O) model provides further insight into the importance of examining student characteristics. If curricular experiences do not take into account current student characteristics as inputs then outcomes assessments are necessarily problematic. Astin indicated that outcomes assessments have frequently been "output-only" measures, calculated without regard to incoming student knowledge, skill, and characteristic differences. As a result, they do not distinguish between how much an observed measurement is the product of institutional programs and how much is due to person-specific, socioeconomic, and cognitive factors. Thus, they are potentially misleading. This presents a considerable problem given increasing demands for curricular and learning outcome accountability.

There has also been general empirical evidence that the characteristics of students from multiple disciplines have changed over time (Astin, Parrott, Korn, & Sax, 1997). There has likewise been attribute-specific empirical evidence that students within the field of engineering had changed even prior to 1996 (Shuman et al., 1996). However, since the Shuman study there has been no published empirical examination of student characteristic changes in engineering.

Further, anecdotally, there has been evidence from leaders in the field that students have changed. For example, Dr. Rogers, Vice President of Institutional Research at Rose-Hulman Institute of Technology (RHIT) and consultant for ABET, has indicated that students have in fact changed and this has presented an increasing challenge directly to instructors and indirectly to engineering educational institutions as a whole (G. Rogers, personal communication, April 1, 2001). She indicated that these challenges have emerged from two competing factors: (a) ABET's emphasis on the need for students to be able to address real world problems, evidence the ability to engage in lifelong learning, and function effectively in teams; and (b) students' apparent increasing tendency toward dualistic thinking rather than the relativistic thinking more in keeping with ABET learning outcome expectations. To this end, there is a notable need specifically in this field for further research into the nature of student change. Thus, this study was designed to delineate student personality, cognitive, and demographic characteristics that are indicators of aggregate differences in undergraduate science and engineering students over time. The purpose of this study was to answer the question "Have engineering student characteristics changed over time?"

## METHOD

### *Sample*

This study used historical data collected by the RHIT Office of Institutional Research, Planning, and Assessment (IRPA). Participants were undergraduate science and engineering students who entered RHIT from 1993 through 2002. Participant data were gathered during the first weeks of student orientation for each cohort including demographic information, assessment results from the LEP (Moore, 1987), and results from the MBTI (Myers & McCaulley, 1985). For the purpose of this study, a database was created by IRPA that excluded identifying information.

*Instrumentation*

Over the past decade IRPA has used multiple instruments during their students' freshman year. Of these, the MBTI and LEP have been regarded as the most institutionally useful, cost-effective, and generalizable to other institutions (G. Rogers, personal communication, April 1, 2001). Thus, the data from these instruments were utilized for this study as opposed to other instrument results available. The MBTI has been used at RHIT consistently throughout the past decade. The LEP has been used only during years in which particular interest has been paid to student learning as it relates to cognitive complexity. Demographic data have likewise been collected with some variance from year to year when additional data were sought.

*The Myers-Briggs Type Indicator.* This inventory is a widely used personality inventory for non-clinical populations (DeVito, 1985). The MBTI Form-G is a self-report, forced choice, personality inventory consisting of 126 items. It is designed to measure preferences on eight indices: Extraversion (E), Introversion (I), Sensing (S), Intuition (N), Thinking (T), Feeling (F), Judgment (J), and Perception (P) (Myers & McCaulley, 1985).

Internal consistency estimates with a sample of 11,908 18-22 year old college students were .82 (E-I), .81 (S-N), .82 (T-F), and .86 (J-P) (Myers & McCaulley). According to Myers and McCaulley, construct validity of the MBTI was evidenced by correlations of MBTI scores with a variety of other scales. The range of correlations was -.40 to -.70 for Extraversion, .40 to .75 for Introversion, -.40 to -.67 for Sensing, .40 to .62 for Intuition, -.40 to -.57 for Thinking, .40 to .55 for Feeling, -.40 to -.59 for Judging, and .40 to .57 for Perceiving.

*Learning Environment Preferences.* Participants of this study completed the LEP during 1993, 1994, 1995, 1996, and 2002. This 165-item self-report measure was developed by Moore (1987) on the basis of Perry's (1970) Schema of Intellectual and Ethical Development. It assesses five domains related to epistemology and approaches to learning: view of knowledge and course content, role of the instructor, role of student and peers in the classroom, classroom atmosphere, and role of evaluation.

It produces results in the form of a Cognitive Complexity Index (CCI). The CCI score ranges from 200 to 500, reflecting a student's level of cognitive complexity according to the Perry 1970 scheme. Normed on the engineering student population, it has particular utility for this study. Internal consistency has ranged from .63 to .66 on the five domains and test-retest reliability at a one-week interval has been found to be .89 (Moore, 1989).

*Demographic Variables.* In terms of demographic variables, IRPA created a database excluding identifying information for the purpose of this study. This included data for age, gender, paternal educational status, maternal educational status, SAT verbal scores, and SAT quantitative scores. These data were selected for this study because learning has been found to vary individualistically by age (Dunn & Griggs, 1995), family academic background, SAT scores (Milgram, Dunn, & Price, 1993), and gender and socioeconomic status (Baxter-Magolda, 1992).

# RESULTS

## *Descriptive Analysis*

MBTI data were obtained during every year of the 10-year period covered by this study. Student data from the LEP were collected during the 1993 - 1996 and 2002 years. Demographic data were collected each year. Descriptive statistics (Table 1) describe the sample in terms of gender, age, parental educational level, SAT verbal scores, and SAT quantitative scores. RHIT first enrolled women beginning in 1995 and they are included in the sample beginning that year.

## *Personality Characteristics*

*Research Hypothesis 1 and Supporting Analysis.* There are no significant differences in the distribution of personality characteristics as measured by the four MBTI dichotomous scales from 1993 - 2002 as measured by Chi-Squares.

Chi-Squares were performed to assess whether there was a significant difference in the distribution of MBTI personality variables. Chi-Squares tested the hypothesis that scores from the four dichotomous scales of the MBTI are independent of the cohorts. Results for Sensing-Intuition are displayed in Table 2 and reveal a significant difference at the .05 level in the distribution of Sensing-Intuition over the sample. This significance value indicates that there may be some connection between Sensing-Intuition and the cohorts. However, nominal directional measures (tau and the Uncertainty Coefficient) show low significance values ($\leq .05$) showing that the difference in the distribution of Sensing-Intuition scores across these cohorts is minimal.

Chi-Square results for Thinking-Feeling (Table 3) similarly indicate a significant difference at the .01 level, though directional measures show considerably low ($\leq .01$) test statistic values for the tau and the Uncertainty Coefficient. This indicates a distributional differential, however negligible. Finally, the Extroversion-Introversion and Perceiving-Judging Chi-Squares were not significant at the .05 level. In other words, there was no significant difference in the distribution of Extroversion-Introversion or Perceiving-Judging over the sample.

*Cognitive Characteristics*

*Research Hypothesis 2 and Supporting Analysis.* There are no significant differences in the mean CCI scores across the 1993, 1994, 1995, 1996, and 2002 cohorts as measured by an ANOVA. Because women entered RHIT in 1995, a second analysis was conducted using an ANOVA to determine if there were significant differences between men's and women's CCI scores for the years 1995 and 2002.

Descriptive analyses for LEP CCI scores were conducted for the 1993, 1994, 1995, 1996, and 2002 cohorts. The 1993 cohort ($M = 351.80$, $SD = 40.51$) had higher CCI scores than any of the remaining cohorts. In fact, comparing the 1993 cohort to the

2002 cohort (*M* = 332.73, *SD* = 48.82), there was 19.07 decrease in CCI scores for the latter. There was also a decline in means from 1993 to 1994 (*M* = 344.11, *SD* = 44.23), 1994 to 1995 (*M* = 336.13, *SD* = 41.34), 1995 to 1996 (*M* = 335.91, *SD* = 45.93), and 1996 to 2002. This presents a notable trend.

An ANOVA was conducted to ascertain whether or not the mean scores of students differed significantly on CCI scores. There was a statistically significant difference in the CCI scores across cohorts, $F(4, 1806) = 11.36, p < .001$. Levine's Test of Homogeneity of Variances was conducted to test the hypothesis that the variances of the groups are the same. A significance value of $p \leq .001$ was obtained demonstrating that the variances are not equal and the assumption was not met. Though the ANOVA is thought to be generally robust to violations of assumptions of this manner, Field (2000) recommends conducting a post hoc analysis such as the Games-Howell due to its sensitivity to unequal variances.

The Games-Howell statistical procedure was chosen because of its utility in situations in which variances are unequal and there are unequal group sizes. Games-Howell test results are presented in Table 4. Inspection of this table reveals significant differences at the .05 level between 1993 and the 1995, 1996, and 2002 cohorts. Likewise, there was a significant difference between the 1994 and 2002 cohorts. Thus, the greatest number of differences were between 1993 and latter cohorts.

Because women entered RHIT in 1995 a subsequent analysis was conducted using an ANOVA to determine if there were significant differences between men's and women's CCI scores for the years 1995 and 2002. A random sample of 148 was selected by means of SPSS 11.5 random selection procedures to allow for an equal number of women and men with LEP CCI scores for both cohorts. An ANOVA was conducted and yielded no statistically significant difference at the .05 level for these cohorts.

*Demographic Characteristics*

*Research Hypothesis 3 and Supporting Analysis.* There are no significant differences in the distribution of demographic variables across 10 years (1993 - 2002). Chi-Squares were utilized for all nominal level variables (gender, ethnicity, parental education) and ANOVAs for all interval level variables (age, SAT scores).

*SAT Verbal Scores.* Descriptive analyses demonstrated relative variance across the 10 cohorts. From 1993 ($M = 540.54$, $SD = 76.03$) to 2002 ($M = 625.96$, $SD = 75.04$) there was an 85.42 increase in SAT verbal scores. Further, there was an increase in mean scores from 1993, 1994 ($M = 534.20$, $SD = 74.14$), and 1995 ($M = 569.48$, $SD = 89.96$). The 1996 ($M = 628.26$, $SD = 85.21$), 1997 ($M = 636.82$, $SD = 76.71$), 1998 ($M = 637.78$, $SD = 80.88$), and 1999 ($M = 642.79$, $SD = 79.08$) cohorts were highest in mean scores.

An ANOVA was conducted to determine whether or not these mean scores differed in a statistically significant manner; it demonstrated a statistically significant difference in SAT verbal scores across cohorts, $F$ (9, 4043) = 103.20, $p < .001$. Levine's Test of Homogeneity of Variances was conducted to test the assumption that the sample variances were equal. The obtained significance value of $p < .001$ indicated that the variances for the cohorts were not equal and the assumption was not met.

Given unequal sample sizes and unequal variances, Games-Howell tests were conducted to further examine significance findings. The Games-Howell tests results (Table 5) revealed the greatest number of significant differences at the .05 level between 1993, 1994, and 1995 cohorts and the remainder of the cohorts. The 1995 cohort presented with significant mean differences between all cohorts. The 1993 and 1994 cohort means differed from all other cohort means except with each other. Likewise, there was a significant difference between the 1997 cohort means and the 2000 cohort means as well as the 2001 cohort means. This pattern replicated in 1998 and 1999.

*SAT Quantitative Scores.* Descriptive analyses for SAT quantitative scores evidenced a pattern similar to the SAT verbal Scores. The lowest scores occurred in 1993 ($M = 662.75$, $SD = 67.19$) and 1994 ($M = 658.19$, $SD = 64.20$). There were increases in the remaining cohorts. The highest scores were during 1997 ($M = 691.54$, $SD = 62.12$), 1998 ($M = 696.96$, $SD = 63.11$), and 1999 ($M = 697.86$, $SD = 63.28$). Overall, there was an increase of 19.62 from 1993 to 2002 ($M = 682.37$, $SD = 61.00$).

An ANOVA was conducted to determine whether these mean scores differed in a statistically significant manner. The ANOVA resulted in a statistically significant difference in the SAT quantitative scores across cohorts, $F\ (9, 4045) = 17.70, p < .001$. Levine's Test revealed a significance value of $p < .04$, showing that the variances for the cohorts were not equal.

To this end, Games-Howell tests (Table 6) were conducted to further examine these significance findings. The Games-Howell tests revealed that the greatest number of significant differences at the .05 level occurred between the 1993 as well as the 1994 cohorts and the remainder of the cohorts. The 1993 and 1994 cohorts differed from all other cohorts. Both the 1998 and 1999 cohorts differed with six other cohorts. The 2000, 2001, and 2002 cohorts differed significantly with four other cohorts.

*Age.* Descriptive analyses indicated that there was little to no variance across the cohorts, though there was a small increase from the 1993 cohort ($M = 18.24$, $SD = .48$) to the 2002 cohort ($M = 18.40$, $SD = .57$). The highest mean age was with the 1999 cohort ($M = 18.59$, $SD = 1.33$) and the lowest was with the 1993 cohort, presenting only a 0.35 difference in age.

Mean ages were analyzed with an ANOVA to determine whether there were significant differences between the cohorts. The ANOVA resulted in a statistically significant difference in age, $F\ (9, 4050) = 8.26$, $p < .001$. Levine's test yielded a significance value of $p < .001$, confirming unequal variances across cohorts. Table 7 displays the Games-Howell test results showing that the greatest number of significant differences at the $p < .05$ level were between 1993 and the remainder of the cohorts. Though significant differences were fairly pervasive throughout the sample, some other patterns were evident. For example, the 1993 and 1995 cohorts differed significantly with the 1999 - 2002 cohorts. There was evidence of statistical significance; however, a 0.35 years difference in age did not represent developmental or practical significance.

*Parental Education.* Table 8 presents the Chi-Square results for parental education with a significant difference at the .01 level. This significance value indicated-that there may be some difference in the distribution of parental education across cohorts. However, the nominal directional measures in this table showed low values for the tau and Uncertainty Coefficient test statistics. This substantiated only negligible differences in the distribution of parental education levels.

*Gender.* Because women entered RHIT in 1995, the analysis conducted for gender is inclusive of the cohorts from 1995 through 2002. Chi-Square results revealed no significant differences at the .05 level.

*Ethnicity.* Chi-Square results likewise revealed no significant differences at the .05 level for ethnicity. This indicated that there is no statistical difference in the distribution of types of ethnicity across cohorts.

## DISCUSSION

Though the results of this study did not represent a statistical confirmation that all identified personality, cognitive, and demographic characteristics of engineering students at RHIT have changed significantly over this past decade, this study's utility is evident in indirect findings. The matter of alpha levels necessary for statistical significance bears consideration. Though only CCI, SAT scores, parental education, and age indicated alpha levels consistent with statistical significance, the results from all analyses demonstrated values that are of practical significance. A result of .10, for example, might not indicate statistical significance at the .05 level, though it does indicate a 90% probability that there is some effect, relationship, or connection between variables. That 90% is practically significant enough to warrant notable consideration when making decisions regarding instructional and institutional changes.

Other indirect value of this study is evident in the observable trends in data. These trends may have a noticeable effect on the landscape of educational service provisions for RHIT in the future. For example, SAT verbal and quantitative scores have increased while cognitive complexity as measured by the LEP has decreased overall. The LEP is designed to assess a student's level of cognitive complexity by determining the student's preferences regarding an ideal learning environment. Lower levels of cognitive complexity are manifested by a preference for learning environments that focus on a dualistic mode of cognition. A student at this stage would prefer instructors who are simple and directive in presenting information to be mastered. Higher levels of cognitive complexity are manifested by a preference for learning environments that focus on more complex, shades-of-gray modes of cognition.

Individuals with high SAT scores demonstrate knowledge attainment and mastery ability. However, high SAT scores are not necessarily reflective of individuals who are capable of interacting in a world demanding flexibility of thought, abstract conceptualization in contexts characterized by a multiplicity of perspectives, the recognition of the need for lifelong learning, and an ability to engage in lifelong learning. Cognitive complexity is more characteristic of these types of individuals (Moore, 1989).

This presents a significant challenge for ABET accredited institutions endeavoring to assure that students are capable of the relativistic interactions and capabilities mandated by the ABET 2004 - 2005 updated standards. The ability to function on multidisciplinary teams, the ability to demonstrate an understanding of professional and ethical responsibility, the ability to communicate effectively, the ability to demonstrate recognition of the need for lifelong learning, and the ability to engage in lifelong learning are all increasingly required. ABET accredited institutions are asked to account for student outcomes in these areas.

*Recommendations*

The results of the present study indicate the need for continuous emphasis on educational interventions needed to address the needs of students who are capable academically, but who may present with particular challenges when faced with relativistic, real-world demands. RHIT staff members have made considerable strides in this direction with their implementation of their E-Portfolio system. It guides students through metacognitive and relativistic thought processes. The incorporation of a multitude of applied approaches to engineering education at RHIT is also to their considerable advantage. However, as the world and the technological structures within it become increasingly complex, demands on the institution for continual improvement processes in this area increase.

Thus, further instruments should be considered that more adequately address student characteristics pertinent to real-world demands. In the area of interpersonal relations and group work, the Fundamental Interpersonal Relations Orientation-Behavior (FIRO-B; Waterman, 1996) is recommended for use in lieu of the MBTI. Waterman indicated that it has been used for over three decades and has appropriate psychometric properties; it is likewise effective in assessing personal, interpersonal, and business related skills that are necessary for meeting the real-world demands of the engineering profession.

In lieu of the MBTI, the NEO Personality Inventory-Revised (NEO-PI-R; Costa & McCrae, 2001) should be used. The NEO-PI-R has a much stronger research and theoretical foundation and will generate more useful and specific results (W. Barratt, personal communication, August, 2002). The NEO-PI-R is based on several decades of factor analytic research and there is substantial research supporting its use with the normal population. It measures five personality domains that summarize emotional, interpersonal, experiential, attitudinal, and motivational styles (Costa & McCrae).

In terms of cognitive attributes, the California Critical Thinking Skills Test-Form 2000 (Facione, 2001) is recommended in that it bears considerable empirical support and uniquely identifies willingness as well as ability to analyze, infer, and evaluate; it measures cognitive complexity from a contextual standpoint, evaluating the application of reasoning abilities within a variety of contexts. This makes it a far more effective tool than the LEP in answering pertinent and practically valuable questions about a student's ability and willingness to apply their cognitive abilities. As previously indicated, a primary struggle with students in the engineering profession has not been the lack of cognitive abilities, but the application of these abilities.

Beyond questions about interpersonal relations, personality, and cognitive attributes is the matter of demographic attributes. As with any archival research, an inherent limitation for this study is that of data availability. It is evident that further data is warranted in order to more adequately address attributes that have a particular bearing on student change. Students' perceptions of learning experiences, extra-curricular interests, cultural interests, educational backgrounds, work experiences, and expectations are essential to understanding the nature of student change; these are attributes that vary from year to year and cohort to cohort (Astin et al., 1997). Examining these demographics in conjunction with cognitive and interpersonal attributes as noted above will provide engineering institutions with far more comprehensive, accurate, and practically valuable information about students. This will enable them to more effectively meet students' educational and service provision needs while providing them with a more meaningful experience. In doing this, engineering institutions will be better able to meet ABET requirements.

Table 1.

*Demographics for Sample*

| | Gender | Ethnicity | Age | Parental education | SAT math | SAT verbal |
|---|---|---|---|---|---|---|
| *N* | 4,070 | 4,069 | 4,060 | 3,477 | 4,055 | 4,053 |
| *M* | 1.15 | 1.13 | 18.37 | 2.12 | 681.69 | 605.54 |
| *SD* | 0.35 | 0.60 | 0.67 | 1.21 | 64.63 | 87.01 |
| Variance | 0.12 | 0.36 | 0.45 | 1.46 | 4,176.39 | 7,571.23 |
| Range | 1 | 5 | 9 | 3 | 320 | 310 |

Table 2

*Chi-Square and Directional Measures for Intuition-Sensing*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 17.36 [a] | 9 | |
| Likelihood Ratio | 17.39 | 9 | |
| Linear-by-Linear Association | 7.17 | 1 | |
| Goodman and Kruskal tau | .00 | | .05 |
| Uncertainty Coefficient | .00 | | .04 |
| *N* of valid cases | 3,942 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 158.88.

Table 3

*Chi-Square and Directional Measures for Thinking-Feeling*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 22.43 [a] | 9 | |
| Likelihood Ratio | 22.68 | 9 | |
| Linear-by-Linear Association | 4.24 | 1 | |
| Goodman and Kruskal tau | .00 | | .01 |
| Uncertainty Coefficient | .00 | | .01 |
| *N* of valid cases | 3,941 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 105.89.

Table 4

*Games-Howell Statistically Significant CCI Pairwise Comparisons*

| | 1993 | 1994 | 1995 | 1996 | 2002 |
|---|---|---|---|---|---|
| 1993 | - | *ns* | 15.67*** | 15.89*** | 19.06*** |
| 1994 | *ns* | - | *ns* | *ns* | 11.38** |
| 1995 | -15.67*** | *ns* | - | *ns* | *ns* |
| 1996 | -15.89*** | *ns* | *ns* | - | *ns* |
| 2002 | -19.06*** | -11.38** | *ns* | *ns* | - |

**$p < .01$. ***$p < .001$.

Table 5

*Games-Howell Significant SAT Verbal Pairwise Comparisons*

| | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|
| 1993 | - | *ns* | 28.84*** | 87.62*** | 96.18*** |
| 1994 | *ns* | - | 35.28*** | 94.06*** | 102.62*** |
| 1995 | -28.84*** | -35.28*** | - | 58.78*** | 67.34*** |
| 1996 | -87.62*** | -94.06*** | -58.78*** | - | *ns* |
| 1997 | -96.18*** | -102.62*** | -67.34*** | *ns* | - |
| 1998 | -97.14*** | -103.58*** | -68.30*** | *ns* | *ns* |
| 1999 | -102.15*** | -108.59*** | -73.31*** | *ns* | *ns* |
| 2000 | -71.94*** | -78.38*** | -43.10*** | *ns* | 24.25*** |
| 2001 | -74.79*** | -81.23*** | -45.95*** | *ns* | 21.39*** |
| 2002 | -85.31*** | -91.76*** | -56.48*** | *ns* | *ns* |

***$p < .001$.

Table 5 (Continued)

*Games-Howell Significant SAT Verbal Pairwise Comparisons*

| | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|
| 1993 | 97.14*** | 102.15*** | 71.94*** | 74.79*** | 85.31*** |
| 1994 | 103.58*** | 108.59*** | 78.38*** | 81.23*** | 91.76*** |
| 1995 | 68.30*** | 73.31*** | 43.10*** | 45.95*** | 56.48*** |
| 1996 | *ns* | *ns* | *ns* | *ns* | *ns* |
| 1997 | *ns* | *ns* | -24.25*** | -21.39*** | *ns* |
| 1998 | - | *ns* | -25.20*** | -22.35*** | -16.83 |
| 1999 | *ns* | - | -30.21*** | -27.36*** | *ns* |
| 2000 | 25.20*** | 30.21*** | - | *ns* | *ns* |
| 2001 | 22.35*** | 27.36*** | *ns* | - | *ns* |
| 2002 | *ns* | 16.83 | *ns* | *ns* | - |

***$p < .001$.

Table 6

*Games-Howell Significant SAT Quantitative Pairwise Comparisons*

| | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|
| 1993 | - | *ns* | 25.19*** | 19.90*** | 28.78*** |
| 1994 | *ns* | - | 29.75*** | 24.46*** | 33.34*** |
| 1995 | -25.19*** | -29.75*** | - | *ns* | *ns* |
| 1996 | -19.90*** | -24.46*** | *ns* | - | *ns* |
| 1997 | -28.78*** | -33.34*** | *ns* | *ns* | - |
| 1998 | -34.21*** | -38.77*** | *ns* | -14.31*** | *ns* |
| 1999 | -35.11*** | -39.67*** | *ns* | -15.21* | *ns* |
| 2000 | *ns* | *ns* | 18.01*** | *ns* | 21.61*** |
| 2001 | -18.85*** | -23.41*** | *ns* | *ns* | *ns* |
| 2002 | -19.62*** | -24.18*** | *ns* | *ns* | *ns* |

Table 6 (Continued)

*Games-Howell Significant SAT Quantitative Pairwise Comparisons*

| | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|
| 1993 | 34.21*** | 35.11*** | *ns* | 18.85** | 19.62*** |
| 1994 | 38.77*** | 39.67*** | *ns* | 23.41*** | 24.18*** |
| 1995 | *ns* | *ns* | -18.01*** | *ns* | *ns* |
| 1996 | 14.31* | 15.21* | -12.72 | *ns* | *ns* |
| 1997 | *ns* | *ns* | -21.61*** | *ns* | *ns* |
| 1998 | - | *ns* | -27.03*** | -15.36* | -14.59* |
| 1999 | *ns* | - | -27.93*** | -16.26** | -15.49** |
| 2000 | 27.03*** | 27.93*** | - | *ns* | *ns* |
| 2001 | 15.36* | 16.26** | *ns* | - | *ns* |
| 2002 | 14.59* | 15.49** | *ns* | *ns* | - |

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 7

*Games-Howell Significant Pairwise Comparisons for Age*

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1993 | - | *ns* | *ns* | .13** | *ns* | *ns* | *ns* | .14*** | .16*** | .16*** |
| 1994 | *ns* | - | *ns* | *ns* | *ns* | *ns* | .28** | *ns* | *ns* | *ns* |
| 1995 | *ns* | *ns* | - | *ns* | *ns* | *ns* | .32*** | .11* | .13*** | .13*** |
| 1996 | -.13*** | *ns* | *ns* | - | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |
| 1997 | *ns* | *ns* | *ns* | *ns* | - | *ns* | *ns* | *ns* | *ns* | *ns* |
| 1998 | *ns* | *ns* | *ns* | *ns* | *ns* | - | .26** | *ns* | *ns* | *ns* |
| 1999 | -.35*** | -.28** | -.32*** | *ns* | *ns* | -.26** | - | *ns* | *ns* | *ns* |
| 2000 | -.14*** | *ns* | -.11* | *ns* | *ns* | *ns* | *ns* | - | *ns* | *ns* |
| 2001 | -.16*** | *ns* | -.13** | *ns* | *ns* | *ns* | *ns* | *ns* | - | *ns* |
| 2002 | -.16*** | *ns* | -.13** | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | - |

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 8

*Chi-Square and Directional Measures for Parental Education*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 49.91 [a] | 27 | |
| Likelihood Ratio | 49.60 | 27 | |
| Goodman and Kruskal tau | .00*** | | .00 |
| Uncertainty Coefficient | .00** | | .01 |
| *N* of valid cases | 4,070 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 40.13.

$^{**}p < .01$. $^{***}p < .001$.

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# APPENDIX A

## The Research Problem

One of the most recent and significant milestones in this engineering education paradigm change was the introduction of Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology 2000 accreditation standards (ABET EC 2000; Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 2000), which were initially proposed in 1995. These standards established outcome-based expectations for student learning in engineering and technology. The ABET EC 2000 criteria emphasized the results of the educational process, as opposed to an evaluation based primarily on curriculum design. The increasing focus on assessment and accountability stemming from ABET EC 2000 has powered a shift away from curriculum-based models that emphasize what is presented toward learning-based models that emphasize student learning outcomes.

This measure of institutional excellence is embedded in the ABET EC 2000 standards that hold institutions accountable for the learning outcomes of students enrolled in their programs. The ABET EC 2000 criteria focuses on the need for students to be able to engage in lifelong learning and demonstrate related skills such as problem solving, the ability to understand the impact of engineering solutions within a broad social context, and the ability to work collaboratively within the context of multiparadigmatic perspectives. These types of knowledge and skills have been deemed vital, given the rapidly changing technology, a knowledge-driven economy, and economic internationalization.

This change in accrediting emphasis from an emphasis on curriculum, or inputs, to an emphasis on short-term and long-term learning outcomes has presented particular challenges for engineering educational institutions. One of the major challenges for institutions in meeting the outcome-based ABET EC 2000 standards (Besterfield-Sacre, et al., 2000) has been that of "converting the desired outcomes into useful metrics for assessment" (p. 33). Further, the utility of these metrics is limited if the metrics are not based on a current knowledge of student characteristics. The outcome emphases and expectations of the ABET EC 2000 criteria as well as its inherent challenges remain equally evident in the 2004 - 2005 updated evaluation criteria for engineering institutions (Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 2003).

Examining the challenge of meeting outcome-based standards through the lens of Astin's (1993) Input-Environment-Outcome (I-E-O) model provides further insight into the importance of examining student characteristics. In Astin's model Inputs (I) refer to the individual characteristics of students upon entering their college experience. Environment (E) refers to aspects of the campus environment (e.g., educational experiences, programs, faculty, living arrangements, and other students) that students encounter. Outcomes (O) refers to the characteristics of students after encounters with the campus environment. As such, Inputs and Experiences both have independent effects on outcomes. Inputs must be taken into account in assessing and understanding both Experiences and Outcomes.

In a student outcome assessment that is designed to examine the "value added" aspect of an education and that uses pre and post measures of student knowledge and skill, a baseline as established by the pre-test is utilized upon which to ultimately evaluate the effect of an instructional program or intervention. If that baseline pre-test is built on historical knowledge or on assumptions regarding student characteristics when student knowledge and characteristics have changed, the outcomes assessment is inherently problematic. Astin (1993) indicated that outcomes assessments have been inherently problematic in that they have frequently been output-only measures. Astin further stated that outcomes-only measures have been calculated without regard to incoming student knowledge, skill, and characteristic differences as well as without regard to how different students experience the college environment.

As a result, the outcome-only measures do not distinguish how much an observed measurement is the product of the institutional programs with how much is due to person-specific, socioeconomic, and cognitive factors. Astin (1993) indicated that when learning outcomes assessments are conducted without regard to individualistic factors they have the potential to be misleading. This presents a considerable problem given the present-day increasing demands for curricular and learning outcome accountability. Underlying this attention to student characteristics as inputs is the knowledge that students with different characteristics learn in different ways, experience learning environments in different ways, and prefer different types of learning experiences.

If students have, in fact, changed over time and this change has been unaccounted for in curricular and outcome assessment design, then students' educational experiences have been less than optimal. There has been empirical evidence that students from multiple disciplines have changed (Astin, Parrott, Korn, & Sax, 1997). There has also been general anecdotal and attribute-specific empirical evidence that students within the field of engineering had changed even prior to 1996 (Shuman et al., 1996). However, since the Shuman study, there has been no published empirical examination of student characteristic changes. Comparatively examining current student characteristics with former student characteristics will provide insights into the status of learning-relevant attributes. Implications can be subsequently drawn regarding student learning outcomes assessments.

*Purpose of the Study*

This study is an investigation designed to delineate student personality, cognitive, and demographic characteristics that are indicators of aggregate differences in entering cohorts of undergraduate science and engineering students. In brief, the purpose of this study is to answer the question "Have student characteristics changed over time?" Given the increasing demands on institutions for curricular reform and outcome assessments of student learning, there is a need for an examination of student characteristics. Student-centered learning is based on assumptions about the characteristics of the students being served (G. Lee-Thomas, personal communication, April 2, 2001). Designing and implementing such instruction is likely to be misdirected if based on inaccurate views. Moreover, with the increasing identification of students as consumers of educational services, evaluating how their characteristics have changed over time will provide insights into how to meet their needs.

*Research Hypotheses*

This study used historical data that had been previously collected at RHIT. The following research hypotheses were examined.

*Research Hypothesis 1*

There are no significant differences in the distribution of personality characteristics as measured by the four MBTI dichotomous scales from 1993 - 2002 as measured by Chi-Squares.

*Research Hypothesis 2*

There are no significant differences in cognitive characteristics as measured by the Cognitive Complexity Index of the Learning Environment Preferences between the 1993, 1994, 1995, 1996, and 2002 cohorts.

*Research Hypothesis 3*

There are no significant differences in the distribution of demographic characteristics across 10 years (1993 to 2002) for all students.

*Operational Definitions of Terms*

To facilitate a better understanding of various terms used throughout this document, operational definitions are provided below:

1. Personality Variables – eight primary personality type indicators as measured by the MBTI: Introversion, Extroversion, Sensing, Intuition, Thinking, Feeling, Perceiving, and Judging.

2. Cognitive Complexity – a continuous range of complexity of thought as measured by the Cognitive Complexity Index of the Learning Environment Preferences.
3. Demographic Variables – learning relevant variables including age, gender, paternal educational status, maternal educational status, SAT verbal scores, and SAT quantitative scores.

*Assumptions*

The following assumptions were made for this study:

1. Participants responded accurately and candidly to the questions in the instruments administered.
2. The participants are individuals without substantial pathology.

*Limitations*

1. This project relies on self-report data and therefore includes inherent limitations, such as subjectivity.
2. The definitions related to personality type, cognitive complexity, student-centered learning, and lifelong learning used in this study may differ from those used in other studies.
3. The composition of the student body predominantly contains traditional students who are selected to attend the institution based on high academic criteria; thus, restricted range is a limitation.

*Delimitations*

1. The participants in this study have been in attendance at Rose-Hulman Institute of Technology. This restricts the generalization of the study's findings to those enrolled subsequently at this institution or other similar institutions.
2. The participants in this study are predominantly European American males with a smaller subgroup of European American females from the United States. Generalizations to other geographical or racial groups would be inappropriate.

# APPENDIX B

## Literature Review

### *Personality Type*

One of the assumptions of Jung's (1923) theory of psychological types is that human behavior is generally orderly and reflects the different ways persons take in information and make decisions. Jung theorized that what appears to be random variation in human behavior is actually quite orderly, logical, and consistent. It is the result of a few basic differences in mental functioning and attitude. These observable differences affect how people interact with the world around them, what people perceive, and how people draw conclusions about those perceptions (Myers & McCaulley, 1985; Zeisset, 1989).

The MBTI is a self-report measure that is fundamentally based on Jungian psychological theory explicating how people consciously prefer to attend to the world, how they choose to perceive that to which they attend, and how they make judgments about those perceptions (Lawrence, 1982). Though it does deviate somewhat from the original assumptions of Jungian theory, the basic structure of the test reflects Jung's typology. The instrument determines respondents' preferences on each of eight dimensions in four dichotomies: Extraversion (E) and Introversion (I), Sensing (S) and Intuition (N), Thinking (T) and Feeling (F), and Judging (J) and Perceiving (P). The instrument is scored in such a way that an individual's stronger preference between these dichotomous pairs becomes that individual's preference, generating a combination of the four preferences.

The MBTI portrays sixteen possible types such as INTJ, ENFP, ISTJ, and the like. that result from the interplay of preferences reflected in the eight dimensions composing the personality types. It is significant to mention here that none of the types or preferences is typically viewed as pathological in nature but reflect normal tendencies in human behavior. The preferences of one type may match the demands of particular situations better than the preferences of other types. The eight MBTI dimensions characterizing these preferences are well described in the literature, especially by McCaulley, Macdaid, & Walsh (1987).

The Extraversion and Introversion scales describe where people prefer to focus their attention and get their energy. Their focus is oriented toward their outer world of people and activity (Extroversion) or their inner world of ideas and experiences (Introversion). Extroversion defines the actions of individuals who prefer an orientation to the outer world of people, places, and things. Introversion describes a preferred orientation toward the inner world of thoughts, concepts, and ideas (Myers & McCaulley, 1985).

The Sensing and Intuition scales describe the ways in which an individual becomes aware of things and people in the experienced environment. Sensing describes a preference to focus on concrete aspects of a situation by using one or more of the five senses. Intuition, on the other hand, describes the focus of attention on abstract ideas made through possibilities, meanings, and relationships associated with a concrete situation.

Thinking and Feeling are both modes of judgment that are used to describe the way in which a conclusion is reached about what has been perceived. These dichotomous scales involve decision-making, evaluation, and selection of appropriate responses to a stimulus. Thinking is characterized by logical connections and more impersonal findings. It is objective. Feeling, on the other hand, describes a rational act of evaluation using subjective values and relative merits of the issues (Zeisset, 1989).

The Perceiving and Judging scales describe the ways in which an individual prefers to approach the world around them and takes in information from their environment. Perceiving tends to take a lead in the individual's relationship with the outside world while Judging governs their inner world. A person who prefers judgment has responded on the MBTI in such a way as to reflect a preference for using a judgment process (either Thinking or Feeling) for dealing with the outer world. On the other hand, a person who prefers perception has reported a preference for using a perceptive process (either Sensing or Intuition) in their encounters with the outer world.

Having knowledge of an individual's psychological type preferences can have far-reaching implications for understanding and interpreting human behavior. It can provide a lens through which student learning can be viewed in context. Psychological type has been shown to affect how students learn as well as how individuals work and communicate (Elias & Stewart, 1991).

For example, knowledge about a student's MBTI scale scores can be utilized to ascertain individual interests within the field of engineering (McCaulley, 1976). McCaulley evaluated 3,867 undergraduate college students to determine psychological type preference using the MBTI. A subset of this student sample was comprised of 194 engineering students. McCaulley sought to determine whether certain psychological types were significantly interested or uninterested in specific engineering specialties. Overall analysis revealed that 62% of engineering students' scores represented dominance in Introversion, 52% in Sensing, 59% in Thinking, and 60% in Judging. These results differed from the total student population evaluated. The analysis of scores for the total population revealed that 52% represented dominance in Extroversion, 53% in Intuition, 63% in Feeling, 50% in Judging, and 50% in Perceiving preferences.

Having knowledge of psychological types can also provide insights into instructional approaches and learning outcomes. Felder and Silverman (1988) analyzed the teaching and learning styles of engineering professors and their students using the MBTI. Their findings identified that the learning styles of most engineering students and teaching styles of most engineering professors were incompatible on several dimensions. Most engineering students were visual, sensing, inductive, and active while most engineering education was centered on auditory, abstract, deductive, passive, and sequential instruction. In summary, these researchers indicated that the disparity of instructional approach and learning preference had created a negative impact on the field of engineering. Their study is yet another support for the need to address the individuality of students and the concomitant need to endorse a stronger student-centered learning approach.

As previously noted and evidenced through the above literature review, the MBTI has wide spread use in the engineering field. It has achieved a great deal of popularity in settings of this nature. However, despite its popularity, the MBTI has been the subject of considerable criticism (e.g., Pittenger, 1993; Sipps, Alexander, & Friedt, 1985). Many criticisms have been raised regarding the MBTI; the foremost of which have been directed toward the measurement properties of the instrument itself, as opposed to the validity of type-based theories or the practical uses of MBTI.

Four major issues along these lines emerge from the literature: (a) claims that the MBTI items do not measure the four main dimensions of personality that it purports to measure (e.g., Sipps, Alexander, & Friedt, 1985), (b) the lack of test-retest personality type stability (e.g., Carlson, 1985; Carskadon, 1982), (c) challenges regarding the fact that MBTI preference score distributions are not typically bimodal, and (d) overall criticisms of the psychometric precision of the MBTI scales (e.g., Pittenger, 1993). Thus, the use of the MBTI results in this study does present a further limitation.

*Cognitive Characteristics*

One of the primary focuses of higher education has been that of facilitating cognitive development and, in particular, cognitive complexity. There is extensive research evidencing the examination of the cognitive development of college students and the conditions that are critical in promoting this development, though these studies have generally been conducted with traditional college students (Astin, 1993; Pascarella

& Terenzini, 1991). However, with the initiation of ABET EC 2000, the cognitive complexity of engineering students has gained increasing attention with particular emphasis on the need for lifelong learners in the field of engineering.

One of the landmark studies frequently referenced in the engineering education literature is Perry's (1970) study of cognitive development. Perry studied the development of students at Harvard University through their four years at the university. His team used open-ended interviews as the technique of measurement. Over a period of years a pattern of development could be distinguished among all the varied responses of the students. Perry then used this pattern of development to rate another group of students. This replication revealed that the scheme was reproducible at least for the men at Harvard University. Subsequent studies since then have essentially duplicated Perry's results and shown that his scheme has fairly general validity.

Other researchers have expanded on Perry's (1970) scheme, suggesting a more relational dimension to cognitive development (Belenky, Clinchy, Goldberger & Tarule, 1986; Gilligan, 1982) in which care for and connections with others influences how the learner functions cognitively. Belenky et al. noted the possibility of conceptual bias in Perry's work due to the absence of women in his sample. To address this conceptual bias, they interviewed women about their perception of themselves as learners, their perceptions of learning, and their perceptions of learning environments. Subsequently, they derived five epistemological perspectives that predominantly paralleled Perry's scheme but also included some significant distinctions.

Further modifications have been suggested for his scheme by several researchers. For example, King and Kitchener (1994) developed the Reflective Judgment Interview by modifying some of Perry's stages (1970). Belenky suggested modifications to increase its applicability to the development of women. Baxter-Magolda (1992) later used the epistemological framework to examine issues in student affairs and gender differences to create the four-stage Epistemological Reflection Model that describes gender-based patterns.

In addition to the first two position categories in Perry's (1970) model (dualism and multiplicity), Belenky et al. (1986) added a position of procedural knowledge, which included a gender-related way of knowing unidentified by Perry. Labeled as "connected knowing," it focused on understanding others' perspectives and suspending judgment in listening. This contrasts with separate knowing which focuses on judging the merits of others' arguments by using the tools of analysis and critical thinking. Belenky et al. further noted other distinctions from Perry's model. For example, they noted that in the dualist mode of thinking men appear to identify with authority figures while women do not necessarily identify with authority figures. A more recent study provided a further integrated view. Baxter-Magolda's (1992) study was an investigation of male and female undergraduate perceptions of the nature of knowledge and the role of gender in their changing patterns of reasoning. Her work suggested that there are more similarities than differences between men and women, although she did find some gender-related patterns.

Even more recent findings have supported Perry's (1970) ideas regarding the changes in beliefs about knowledge being the byproduct of exposure to a multiplicity of viewpoints. His research has been supported by findings of similar changes as a function of increasing age and experiences by researchers using different methodologies (Kitchener, 1983; Schommer, 1994). However, some attempts to liken Perry's scheme to metacognitive functioning have produced mixed results. Ryan (1984) conducted a study in which he classified students as either highly dualistic or highly relativistic. Dualists in this study used a fact-oriented approach whereas relativists used a context-oriented manner.

Schommer (1990) initiated research that attempted to resolve the conflicting results of research obtained by Ryan (1984). This inconsistency between Ryan's results and Perry's (1970) was purported to be due to differing conceptions of epistemological beliefs. Ryan's interpretation of Perry's work was based upon the assumption that personal epistemology is a one-dimensional phenomenon, developing in a fixed progression of stages. Though debate exists regarding this, a more plausible conception is that personal epistemology is a system of more or less independent dimensions. Epistemological beliefs are far too complex to be captured in a single dimension (Schommer, Crouse, & Rhodes, 1992; Schommer, 1994).

Utilizing such instruments as the Learning Environment Preferences (LEP), Moore (1987) likewise addressed this issue of single and multiple dimensions of development and epistemological beliefs. The Learning Environment Preferences is based on Perry's (1970) scheme and provides indices indicating a student's standing relative to Perry's nine positions of epistemological development. Yet, it also provides the Cognitive Complexity Index (CCI), which is a numerical reference to a student's cognitive complexity on a continuous scale. The Learning Environment Preferences has particular utility for this study given the fact that it can be used to extract an index of cognitive complexity as well as the fact that it has been normed on the engineering student population.

*Demographic Characteristics*

The examination of demographic variables is significant to this study given its significance to student learning as a whole, in addition to its relevance to student outcomes assessment. In the field of student outcomes assessment Astin (1993) has highlighted the importance of demographics by identifying them as input variables in his I-E-O model. Individual differences, as measured by demographic variables contribute independently to student outcomes and are a necessary part of student outcomes assessment.

In the area of student learning, studies have also shown that learning has been found to vary individualistically by demographics variables such as age (Cross, 1992), family academic background (Baxter-Magolda, 1992), and gender (Baxter-Magolda, 1992; Clinchy, 1990). Learning styles have also been shown to vary with age (Dunn & Griggs, 1995), SAT achievement level (Milgram, Dunn, & Price, 1993), gender, and socioeconomic status (Baxter-Magolda, 1992). The results of the UCLA 30-year longitudinal study (Astin et al., 1997) indicated that environmental factors, experiential expectations, and individual interests are likewise essential demographically to a thorough assessment of student change. Given the archival nature of the present study, these factors were not addressed. They would be significant to incorporate in subsequent research.

# APPENDIX C

## Methods

*Sample*

This study used historical data previously collected by the RHIT Office of Institutional Research, Planning, and Assessment. Participants were undergraduate science and engineering students who entered RHIT from 1993 through 2002. Demographic information, assessment results from the Learning Environment Preferences, and assessment results from the Myers-Briggs Type Indicator were obtained through the Institutional Research, Planning, and Assessment Office. For the purpose of this study, a database was created by this office in such a manner that identifying information was not included in the database making it impossible for the researcher to link assessment results or demographic information to personally identifying information. In short, anonymity was maintained.

*Instrumentation*

Over the past decade, the Rose-Hulman Institute of Technology Office of Institutional Research, Planning, and Assessment has used multiple instruments during their students' freshman year. Two of these instruments have been the (a) the Learning Environment Preferences, and (b) the Myers-Briggs Type Indicator. The MBTI has been used consistently throughout the past decade. The LEP has been used during years in which particular interest has been paid to student learning as it relates to cognitive complexity.

*Learning Environment Preferences.* During the years of 1993, 1994, 1995, 1996, and 2002, the participants completed the Learning Environment Preferences. The LEP is an inventory developed by Moore (1987) on the basis of Perry's (1970) Schema of Intellectual and Ethical Development. The LEP assesses five domains related to epistemology and approaches to learning: view of knowledge and course content, role of the instructor, role of student and peers in the classroom, classroom atmosphere, and role of evaluation. For the purposes of this research, the Cognitive Complexity Index (CCI) scale was used from the LEP.

The LEP is a self-report inventory measure consisting of 165 items used to gather information concerning learning preferences and cognitive complexity. It was derived from the Measure of Intellectual Development (MID), an essay-based assessment tool (Moore, 1988). Scores are derived from five 58 content domains each including 13 specific questions. These content domains are (a) a view of knowledge and course content, (b) the role of the instructor, (c) the role of the student and peers in the classroom, (d) the classroom atmosphere, and (e) the role of evaluation. Each item is rated in terms of a 4-point Likert scale according to its significance to the person's ideal learning environment.

The Cognitive Complexity Index (CCI) score is derived by a formula applied to an individual's responses with the resulting score ranging from 200 to 500 reflecting their level of cognitive complexity according to the Perry scheme. The first position of Perry's

(1970) scheme has not been demonstrated to exist in college populations and therefore is not included in the LEP or calculated in the CCI. Positions six through nine were believed to only be accessible through in-depth interviews and therefore are not included in the LEP. Internal consistency ranges have been from .63 to .66 on the five domains and from .72 to .84 on positions two to four. Test-retest reliability at a one-week interval of the CCI has been found to be .89 according to Moore (1987).

*Myers-Briggs Type Indicator.* This inventory is a widely used personality inventory for non-clinical populations (DeVito, 1985; Lynh, 1985). The MBTI Form-G is a self-report forced choice personality inventory consisting of 126 items. It is designed to measure preferences on eight indices: Extraversion (E), Introversion (I), Sensing (S), Intuition (N), Thinking (T), Feeling (F), Judgment (J), and Perception (P) (Myers & McCaulley, 1985).

There are four indices subdivided into two attitudes and two functions, or processes. One attitude describes how individuals are energized (Extraversion-Introversion) and the other attitude describes how they live their lives (Judging-Perceiving). One function describes how individuals perceive information (Sensing-Intuition) and the other function describes how individuals make decisions (Thinking-Feeling). An individual score is generally reported as the higher of each of these pairs. For example, an individual whose Extroversion score is higher than the Introversion scale score is reported as an Extrovert. In this research respondents' highest scores on each of the four dichotomous scales was used.

This is in keeping with Mental Measurement Yearbook notations that the MBTI shows evidence of validity as four separate personality scales (Swanson, 1995). It is also consistent with the views regarding the usage of ipsative instrument data. Accordingly, the MBTI profile data may only conventionally be expressed in a nominal format; this is due to the ipsative nature of the instrument (Bartram, 1996; Closs, 1996). Further, the underlying theory (Myers & McCaulley, 1985) of the MBTI presents each scale as two dichotomous points rather than a continuum. Some validity and reliability studies assume each scale is continuous in spite of this fact.

Although there are studies that criticize the psychometric properties of the MBTI, several confirmatory factor analyses of the MBTI have been reported and their results have consistently supported the validity of the predicted 4-factor structure (e.g., Harvey, Murry, & Stamoulis, 1995; Johnson & Saunders, 1990). When considered on its own, the predicted MBTI factor structure has been found to provide a plausible representation of its latent structure (Johnson & Saunders).

Internal consistency estimates with a sample of 11,908 traditional (18-22 year old) college students were .82 (EI), .81 (SN), .82 (TF), and .86 (JP) (Myers & McCaulley, 1985). Five-week test-retest reliabilities using product-moment correlations of continuous scores ranged between .77 and .89 (EI), .85 to .93 (SN), .56 to .91 (TF), and .87 to .89 (JP) (Carskadon, 1982). According to Myers and McCaulley, construct validity of the MBTI was evidenced by correlations of MBTI with a variety of other scales (e.g., Minnesota Multiphasic Personality Inventory, Dahlstrom & Welsh, 1960; and Strong-Campbell Interest Inventory, Campbell & Hansen, 1981). The range of correlations was -

.40 to -.70 (Extraversion), .40 to .75 (Introversion), -.40 to -.67 (Sensing), .40 to .62 (Intuition), -.40 to -.57 (Thinking), .40 to .55 (Feeling), -.40 to -.59 (Judging), and .40 to .57 (Perceiving).

*Demographic Variables.*

Data for age, gender, paternal educational status, maternal educational status, SAT verbal scores, and SAT quantitative scores were drawn from the institutional database.

# APPENDIX D

## Extended Results

*Descriptive Analysis*

The data were obtained for the MBTI during the 10-year period covered by this study, but data from the other instruments was not consistently collected over time. Table F1 shows the years of the study measures collected. Women were included in the data gathering beginning in 1995 when RHIT first enrolled women. Descriptive statistics (Table 1) describe the participant sample in terms of gender, age, parental educational level, SAT verbal scores, and SAT quantitative scores.

*Personality Characteristics*

*Research Hypothesis 1 and Supporting Analysis.* There are no significant differences in the distribution of personality characteristics as measured by the four dichotomous scales of the MBTI across 10 years (1993 to 2002) for all students as measured by Chi-Squares.

Chi-Squares were performed to assess whether there was a significant difference in the distribution of MBTI personality variables. Chi-Squares tested the hypothesis that scores from of the four dichotomous scales of the MBTI are independent of the cohorts. For Sensing-Intuition, frequency counts are displayed in Table F2. The Chi-Square test results for Sensing-Intuition are displayed in Table F3. They revealed a significant difference at the $p < .05$ level in the distribution of Sensing-Intuition over the sample.

This significance value indicated that there may be some relationship between Sensing-Intuition and cohort distribution.

While the Chi-Square measures indicated that there may be a relationship between various variables, they did not indicate the strength or direction of the relationship. However, the nominal directional measures (Table F4) indicated both the strength and significance of the relationships. The value of each statistic in Table F4 ranged from zero to one and indicated the proportional reduction in error in predicting the value of Sensing-Intuition based upon the overall cohort values. Test statistic values shown in the .01 range indicated that error rate has been reduced by approximately one percent over what would be expected by random chance. There were low significance values ($p \leq .05$) for the tau and the Uncertainty Coefficient. The low values for both test statistics substantiated the fact that the differences in the distribution of Sensing-Intuition scores was limited.

Frequency counts for Thinking-Feeling are displayed in Table F5. Chi-Square results displayed in Table F6 indicated a significant difference at the $p < .01$ level for Thinking-Feeling showing that there may be some relationship between Thinking-Feeling and the cohorts. However, directional measures (Table F7) indicated test statistic values less than or equal to .01, showing that error rate has been reduced by less than or equal to one percent over what would be expected by random chance. To this end, there were low significance values ($p \leq .06$) for Lambda, tau, and Uncertainty Coefficient. The low values for both corresponding test statistics showed that the differences in the distribution of Thinking-Feeling scores was limited much the same way as it was for Sensing-Intuition.

For Extroversion-Introversion, frequency counts are displayed in Table F10. Chi-Square test results in Table F11 indicated that there was not a significant difference in the distribution of Extroversion-Introversion over the sample. Results were similar for Perceiving-Judging. Frequency counts are shown in Table F8 and Chi-Square results shown in Table F9. There was not a significant difference in the distribution of Perceiving-Judging over the sample.

*Cognitive Characteristics*

*Research Hypothesis 2 and Supporting Analysis.* There are no significant differences in the mean CCI scores across the 1993, 1994, 1995, and 2002 cohorts as measured by an ANOVA. Because women entered RHIT in 1995, a second analysis was conducted using an ANOVA to determine if there were significant differences between men's and women's CCI scores for the years 1995 and 2002.

Table F12 presents the descriptive analyses for LEP CCI scores for the 1993, 1994, 1995, 1996, and 2002 cohorts. Inspection of this table reveals that the 1993 cohort ($M = 351.80$, $SD = 40.51$) presented with higher CCI scores than any of the remaining cohorts. In fact, compared to the 2002 cohort ($M = 332.73$, $SD = 48.82$), there was a decrease of 19.07 in CCI scores for the latter. In addition, there was an observable decline in mean scores from 1993 to 1994 ($M = 344.11$, $SD = 44.23$), 1994 to 1995 ($M = 336.13$, $SD = 41.34$), 1995 to 1996 ($M = 335.91$, $SD = 45.93$), and 1996 to 2002.

An ANOVA was conducted to ascertain whether or not these mean scores differed significantly. Results of this analysis indicated that there was a statistically significant difference in the CCI scores across cohorts, $F$ (4, 1806) = 11.36, $p < .001$ (Table F13). Levine's Test of Homogeneity of Variances (Table F14) was conducted to test the hypothesis that the variances of the groups are the same. Levine's Test is essentially an ANOVA conducted on the absolute differences between the observed data and the mean derived from the data. Therefore, Levine's procedure is testing whether the variances of the CCI groups are significantly different. The obtained significance value of $p < .001$, indicated that the variances for the cohorts were not equal and the assumption was not met. Though the ANOVA is thought to be generally robust to violations of assumptions of this manner, Field (2000) suggested that Games-Howell post hoc tests would be advisable in such cases given its sensitivity to unequal variances.

Games-Howell tests were designed to be used in situations in which variances are unequal and also take into account unequal group sizes. Severely unequal variances can lead to increased Type I error and with smaller sample sizes more moderate differences in group variance can lead to increases in Type I error. This test is thought to be better than other measures, such as the Tukey HSD or Dunnet's, if variances are very unequal and there are unequal sample sizes (Field, 2000; Kromrey & La Rocca, 1995). Because the given data set has both unequal variances and unequal group sizes the Games-Howell test was deemed appropriate for this analysis. Games-Howell test results are presented in Table F15. Inspection of this table reveals significant differences at the $p < .05$ level between 1993 and the 1995, 1996, and 2002 cohorts. Likewise, there was a significant difference between the 1994 and 2002 cohorts. Thus, the greatest number of differences were between 1993 and latter cohorts.

Because women entered RHIT in 1995 a subsequent analysis was conducted using an ANOVA to determine if there were significant differences between men's and women's CCI scores for the years 1995 and 2002. Table F16 shows the descriptive statistics for this sample. A random sample of 148 was selected by means of SPSS 11.5 random selection procedures to allow for an equal number of women and men with LEP CCI scores for both cohorts. Results of the ANOVA are presented in Table F17 showing no statistically significant differences in CCI scores for these cohorts.

*Demographic Characteristics*

*Research Hypothesis 3 and Supporting Analysis.* There are no significant differences in the distribution of demographic variables across 10 years (1993 - 2002). Chi-Squares were utilized for all variables that were nominal data (gender, ethnicity, parental education). An ANOVA was used for all variables that were interval level data (age, SAT verbal scores, SAT quantitative scores).

*SAT Verbal Scores.* Table F18 presents descriptive analyses for SAT verbal scores across the 10 cohorts. Inspection of this table reveals a relative variance in scores across the 10 cohorts. However, from the 1993 cohort ($M = 540.54$, $SD = 76.03$) to the 2002 cohort ($M = 625.96$, $SD = 75.04$), there was an 85.42 increase in SAT verbal scores. There was also an increase in mean scores from 1993 to 1994 ($M = 534.20$, $SD = 74.14$) and 1995 ($M = 569.48$, $SD = 89.96$). There were further increases in subsequent cohorts. The 1996 ($M = 628.26$, $SD = 85.21$), 1997 ($M = 636.82$, $SD = 76.71$), 1998 ($M = 637.78$, *SD* = 80.88), and 1999 (*M* = 642.79, *SD* = 79.08) cohorts presented with the highest mean scores.

An ANOVA was conducted to determine whether or not these mean scores differed in a statistically significant manner. This analysis demonstrated a statistically significant difference in SAT verbal scores across cohorts, $F$ (9, 4043) = 103.20, $p < .001$ (Table F19). Levine's test (Table F20) was conducted to test the assumption that the sample variances were equal. The significance value of $p < .001$ indicated that the variances for the cohorts were not equal and the assumption was not met.

Given unequal sample sizes and unequal variances, Games-Howell post hoc analyses were conducted to further examine significance findings. Games-Howell test results (Table F21) revealed the greatest number of significant differences at the $p < .05$ level between the 1993 - 1995 cohorts and the remainder of the cohorts. The 1995 cohort presented with significant differences in means between all cohorts. The 1993 and 1994 cohorts differed from all other cohorts except with each other. Likewise, there was a significant difference between the 1997 cohort and the 2000 and 2001 cohorts. This pattern was replicated in 1998 and 1999.

*SAT Quantitative Scores.* Table F22 presents descriptive analyses for SAT quantitative scores across the 10 cohorts. A pattern similar to the SAT verbal Scores was evident in SAT quantitative scores. The lowest scores were present in 1993 (*M* = 662.75, *SD* = 67.19) and 1994 (*M* = 658.19, *SD* = 64.20) with observable increases in the remaining cohorts. The highest scores were during 1997 (*M* = 691.54, *SD* = 62.12), 1998

(*M* = 696.96, *SD* = 63.11), and 1999 (*M* = 697.86, *SD* = 63.28). Overall, there was an increase of 19.62 from 1993 to 2002 (*M* = 682.37, *SD* = 61.00).

These scores were analyzed with an ANOVA to determine whether or not the observed differences between the cohorts were statistically significant. The ANOVA resulted in a statistically significant difference in the SAT quantitative scores across cohorts, $F$ (9, 4045) = 17.70, $p < .001$ (Table F23). Levine's Test of Homogeneity of Variances (Table F24) was conducted to test the assumption that the sample variances were equal. The significance value of .04 confirmed that the variances for the cohorts were not equal and the assumption was not met.

Thus, Games-Howell post hoc analyses were conducted to further examine these significance findings. The Games-Howell post hoc analyses (Table F25) demonstrated that the greatest number of significant differences at the $p < .05$ level was between the 1993 and 1994 cohorts and the remainder of the cohorts. The 1993 and 1994 cohorts differed from all other cohorts though were similar to each other. Both the 1998 and 1999 cohorts differed with six other cohorts. The 2000, 2001, and 2002 cohorts differed significantly with four other cohorts.

Further examining the results of SAT verbal and SAT quantitative scores in light of CCI scores revealed trends that are significant to explore. As previously noted, CCI scores have successively decreased over the 10 cohorts. At the same time, SAT verbal and SAT quantitative scores have increased. This brought to question matters that were originally beyond the hypotheses of this research though warrants further consideration.

In order to further examine these overall trends, correlations were conducted on all cohorts between SAT scores and CCI scores. An overall correlation between SAT verbal scores and CCI scores across all cohorts resulted in a .11 correlation. Results of SAT quantitative and CCI scores across all cohorts showed a .12 correlation. Year by year correlations are shown in Table F26. This table reveals one statistically significant correlation for the 1995 cohort in terms of SAT quantitative scores. Though this is the only statistically significant correlation, the other correlations shown (ranging from .10 to .33) reveal a 67% to 90% probability that there is some correlation between SAT scores and CCI.

*Age*. Descriptive analyses for the demographic variable of age are presented in Table F26. Inspecting this table there appears to be little to no variance across the cohorts. However, there is somewhat of an increase from 1993 ($M = 18.24$, $SD = .48$) to 2002 ($M = 18.40$, $SD = .57$). The highest mean age was with the 1999 cohort ($M = 18.59$, $SD = 1.33$) and the lowest mean age was with the 1993 cohort. This presents only a 0.35 difference in age.

Mean ages were analyzed with an ANOVA to determine whether there were significant differences between the cohorts. The ANOVA resulted in a statistically significant difference in the age, $F$ (9, 4050) = 8.26, $p < .001$ (Table F28). Levine's Test of Homogeneity of Variances was conducted to test the assumption that the sample variances were equal. The significance value of $p < .001$ showed that the variances for the cohorts were not equal and the assumption was not met.

Games-Howell post hoc analyses were conducted and the analyses (Table F29) revealed that the greatest number of significant differences at the $p < .05$ level were between 1993 and the remainder of the cohorts. Though significant differences were fairly pervasive throughout the sample, some other patterns were evident. For example, the 1993 and 1995 cohorts differed significantly with the 1999 through 2002 cohorts. These were the only significant differences in the 2000 through 2002 cohorts. To this end, these results are evidence of statistical significance. However, developmentally, there is not necessarily any practical difference between a student who is, for example, 18.24 years old and a student who is 18.59 years old. Thus, practical significance is questionable.

*Parental Education*. Frequency counts are displayed in Table F30. The Chi-Square results for parental education are presented in Table F31 and reveal a significant difference at the $p < .01$ level in the distribution of parental education levels over the sample. This significance value indicates that there may be some relationship between parental education and the cohorts.

However, the nominal directional measures (Table F32) indicate both the strength and significance of the relationship. As such, the test statistic values shown in the 0.01 range in Table F32 indicate that error rate has been reduced by only approximately one percent over what would be expected by random chance. There are low significance values ($p \leq .06$) for the Lambda, tau, and Uncertainty Coefficient. However, the low values for the corresponding test statistics indicate a weak relationship between parental education and the cohorts.

*Gender*. Because women entered RHIT in 1995 the analysis conducted for gender is inclusive of the cohorts from 1995 through 2002. Frequencies for gender are presented in Table F33. Chi-Square results shown in Table F34 reveal no significant differences at the $p < .05$ level.

*Ethnicity*. Frequency counts for ethnicity are presented in Table F34. Chi-Square results (Table F35) revealed no significant differences at the $p < .05$ level. This indicates that there is no statistical difference in the distribution of types of ethnicity across cohorts. Essentially, the distribution of types of ethnicity was the same across all cohorts.

# APPENDIX E

## Extended Discussion and Recommendations

### *Personality Characteristics*

Analyses of personality characteristics revealed the following: (a) The relationship between Sensing-Intuition and the cohorts is fairly weak, (b) the relationship between Thinking-Feeling and the cohorts is weak in much the same way as it is for Sensing-Intuition, (c) there was not a significant difference in the distribution of Extroversion-Introversion over the sample, and (d) there was no significant difference in the distribution of Perceiving-Judging over the sample. Thus, there is limited statistical evidence that personality characteristics as measured by the MBTI are different.

As previously noted, the psychometric criticisms of the MBTI present a substantial limitation to this study. Future research will need to incorporate the use of other measures for assessing student characteristics. Instruments such as the Index of Learning Styles (ILS; Soloman and Felder, 2001) have been similarly used in engineering institutions to assess interpersonal and learning attributes. However, the ILS presents with similar limitations. According to Soloman and Felder, there have been no reliability and validity studies conducted on the measure. In addition, both the MBTI and the ILS do not thoroughly examine the student attributes that are receiving increasing attention in the engineering education community.

Leaders in the science and engineering industry (e.g., Committee on Science, Engineering, & Public Policy, 1995; Stevens & Burley, 2003) have stated that there is a need for science and engineering students to have ultimately developed business-related skills such as project management, team-building, interpersonal communication, creativity, and entrepreneurship in addition to the technical skills they gain from traditional instruction. In conjunction with academic preparation, it has been strongly recommended that science and engineering students possess some capacity to obtain skills needed in the business and industry arenas (National Science Foundation, 2002). In fact the National Science Foundation (NSF) has supported the concept of joining traditional science and engineering training with business-related education by funding the development of a number of multidisciplinary degree programs in these fields due to the identification of the importance of these qualities.

Given the importance of these areas, the Fundamental Interpersonal Relations Orientation-Behavior (FIRO-B; Waterman, 1996) would be a particularly valuable instrument to utilize in further examining these types of student characteristics. Waterman indicated that it has been used for over three decades and has appropriate psychometric properties; it has likewise been effective in assessing interpersonal relating and overall business related skills. It has been used to measure and assist with team building, management, and communication.

*Cognitive Characteristics*

Analyses of cognitive complexity revealed that there were significant differences at the $p < .05$ level between 1993 and the 1995, 1996, and 2002 cohorts. Likewise, there was a significant difference between the 1994 and 2002 cohorts. The greatest number of significant differences was between 1993 and latter cohorts. This indicates that the hypothesis that cognitive characteristics for this sample have changed over time is unsubstantiated; statistically significant differences in cognitive complexity are present across the examined cohorts.

However, the practical significance of a difference in cognitive complexity from 351.80 (1993) to 332.73 (2002) is unimportant. Individuals with scores in the near vicinity of either of these means would have the same level of cognitive complexity (Moore, 1987; 1989). It should further be noted here that there was no gender-related significance, which is contrary to Baxter-Magolda's (1992) assertions regarding the differences in intellectual development between men and women.

*Demographic Characteristics*

For both the SAT verbal scores SAT quantitative scores, the greatest number of significant differences were found to be between the 1993 -1995 and the remainder of the cohorts. The 1995 cohort presented with significant differences in means between all cohorts and the 1993 and 1994 cohorts differed from all other cohorts, except with each other for SAT verbal scores. Likewise, there was a significant difference between 1997 cohort and the 2000 and 2001 cohorts. This pattern was replicated in 1998 and 1999. Significant differences were more varied and pervasive with the SAT qualitative scores. Both the 1998 and 1999 cohorts differed with six other cohorts and the 2000, 2001, and 2002 cohorts differed significantly with four other cohorts.

Overall the means for both SAT verbal and SAT quantitative scores have increased over the past decade with the greatest increase evident in SAT verbal scores. It is likely that this increase is related to the increasing competitiveness of entry into RHIT. However, this increase supports the alternative hypothesis that this aspect of student demographic characteristics has changed over time.

The above findings are similar to the statistical findings regarding age, particularly with regard to the contrast between the earlier cohorts and the latter. This is a clear example of how statistical significance differs from practical significance. The highest mean age was with 18.59 (1999) and the lowest mean age was 18.24 (1993), representing only a 0.35 difference in age. This is unlikely to have a practically significant effect on the nature of the students attending RHIT. Similarly, though there is somewhat of a trend in parental educational levels from first time college student to both parents as college graduates, parental education analyses revealed only a weak relationship between parental education levels and the cohorts. The relationship that does exist is not only weak, but would not be practically significant. Gender and ethnicity analyses revealed no statistically significant differences and the differences were likewise not practically significant.

*Implications*

Though the results of this study did not represent a statistical confirmation that all identified personality, cognitive, and demographic characteristics of engineering students at RHIT have changed over this past decade, this study's utility is particularly evident in indirect findings. As previously discussed, the matter of alpha levels and practical significance bears consideration. Data trends also bear potential implications and may have a noticeable effect on the landscape of educational service provisions for RHIT in the future. Finally, the psychometric limitations of the MBTI as well as the increasing focus on attributes that the MBTI does not measure indicates that other instruments such as the FIRO-B warrant consideration. The NEO-PI-R was recommended because it adequately measures real-world interpersonal functioning. Cognitively, the California Critical Thinking Skills Test (CCTST; Facione, 2001) was similarly recommended given its utility and empirical support.

*Recommendations*

The results of this study indicate the need for continuous emphasis on educational interventions to address the needs of students who are capable academically, but who may present with particular challenges when faced with relativistic, real-world demands. RHIT staff members have made considerable strides in this direction with their implementation of their E-Portfolio system. The E-Portfolio system guides students through metacognitive and relativistic thought processes. RHIT's incorporation of a multitude of applied approaches to engineering education is also to their considerable advantage.

However, as the world and the technological structures within it become increasingly complex, demands on the institution for continual improvement processes in this area increase. Thus further research is recommended to identify student attributes and their changes relative to real-world demands. The data set utilized was not able to fully illuminate real or perceived differences in students over time. As previously noted instruments such as the FIRO-B, NEO-PI-R, and CCTST will prove more effective in identifying these types of characteristics. Further examination into the demographic attributes that impact student change is also warranted as is examination into those attributes that are related to actual student functioning within their social and educational environment.

# APPENDIX F

## Tables

Table F1

*Data Obtained*

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| MBTI | X | X | X | X | X | X | X | X | X | X |
| CCI | X | X | X | X | | | | | | X |
| Demographics | X | X | X | X | X | X | X | X | X | X |
| Women | | | X | X | X | X | X | X | X | X |

Table F2

*Frequency Counts for Intuition-Sensing*

| Cohort | Intuition | Sensing | Total |
|---|---|---|---|
| 1993 | 210 | 151 | 361 |
| 1994 | 189 | 147 | 336 |
| 1995 | 251 | 189 | 440 |
| 1996 | 185 | 182 | 367 |
| 1997 | 195 | 182 | 377 |
| 1998 | 210 | 205 | 415 |
| 1999 | 191 | 190 | 381 |
| 2000 | 220 | 206 | 426 |
| 2001 | 185 | 207 | 392 |
| 2002 | 242 | 205 | 447 |
| Total | 2,078 | 1,864 | 3,942 |

Table F3

*Chi-Square Tests for Intuition-Sensing*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 17.36 [a]* | 9 | .04 |
| Likelihood Ratio | 17.39* | 9 | .04 |
| Linear-by-Linear Association | 7.17** | 1 | .01 |
| *N* of valid cases | 3,942 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 158.88.

$^{*}p < .05$. $^{**}p < .01$.

Table F4

*Directional Measures for Intuition-Sensing*

| | Value | *SE* | *p* |
|---|---|---|---|
| Lambda | | | |
| Symmetric | .01 | .01 | .43 |
| Cohort dependent | .00 | .01 | .72 |
| Intuition-Sensing dependent | .01 | .01 | .27 |
| Goodman and Kruskal tau | | | |
| Cohort dependent | .00* | .00 | .05 |
| Intuition-Sensing dependent | .00* | .00 | .04 |
| Uncertainty Coefficient | | | |
| Symmetric | .00* | .00 | .04 |
| Cohort dependent | .00* | .00 | .04 |
| Intuition-Sensing dependent | .00* | .00 | .04 |

*$p < .05$.

Table F5

*Frequency Counts for Thinking-Feeling*

| Cohort | Thinking | Feeling | Total |
|---|---|---|---|
| 1993 | 230 | 131 | 361 |
| 1994 | 233 | 103 | 336 |
| 1995 | 300 | 140 | 440 |
| 1996 | 237 | 130 | 367 |
| 1997 | 263 | 113 | 376 |
| 1998 | 288 | 127 | 415 |
| 1999 | 275 | 106 | 381 |
| 2000 | 285 | 141 | 426 |
| 2001 | 252 | 140 | 392 |
| 2002 | 336 | 111 | 447 |
| Total | 2,699 | 1,242 | 3,941 |

Table F6

*Chi-Square Tests for Thinking-Feeling*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 22.43 [a] ** | 9 | .01 |
| Likelihood Ratio | 22.68** | 9 | .01 |
| Linear-by-Linear Association | 4.24* | 1 | .04 |
| *N* of valid cases | 3,941 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 105.89.

*$p < .05$. **$p < .01$.

Table F7

*Directional Measures for Thinking-Feeling*

| | Value | *SE* | *p* |
|---|---|---|---|
| Lambda | | | |
| Symmetric | .01 | .00 | .06 |
| Cohort dependent | .01 | .01 | .06 |
| Thinking-Feeling dependent | .00 | .00 | .00 |
| Goodman and Kruskal tau | | | |
| Cohort dependent | .00** | .00 | .01 |
| Thinking-Feeling dependent | .00** | .00 | .01 |
| Uncertainty Coefficient | | | |
| Symmetric | .00** | .00 | .01 |
| Cohort dependent | .00** | .00 | .01 |
| Thinking-Feeling dependent | .01** | .00 | .01 |

$^{**}p < .01$.

Table F8

*Frequency Counts for Perceiving-Judging*

| Cohort | Perceiving | Judging | Total |
|---|---|---|---|
| 1993 | 194 | 162 | 356 |
| 1994 | 194 | 142 | 336 |
| 1995 | 251 | 189 | 440 |
| 1996 | 200 | 167 | 367 |
| 1997 | 207 | 170 | 377 |
| 1998 | 202 | 213 | 415 |
| 1999 | 215 | 166 | 381 |
| 2000 | 241 | 185 | 426 |
| 2001 | 205 | 187 | 392 |
| 2002 | 257 | 190 | 447 |
| Total | 2,166 | 1,771 | 3,937 |

Table F9

*Chi-Square Tests for Perceiving-Judging*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 11.57 [a] | 9 | .24 |
| Likelihood Ratio | 11.54 | 9 | .24 |
| Linear-by-Linear Association | .04 | 1 | .83 |
| *N* of valid cases | 3,937 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 151.14.

Table F10

*Frequency Counts for Extroversion-Introversion*

| Cohort | Extroversion | Introversion | Total |
|---|---|---|---|
| 1993 | 125 | 236 | 361 |
| 1994 | 140 | 196 | 336 |
| 1995 | 182 | 258 | 440 |
| 1996 | 162 | 205 | 367 |
| 1997 | 164 | 213 | 377 |
| 1998 | 165 | 250 | 415 |
| 1999 | 161 | 220 | 381 |
| 2000 | 170 | 256 | 426 |
| 2001 | 151 | 241 | 392 |
| 2002 | 196 | 251 | 447 |
| Total | 1,616 | 2,326 | 3,942 |

Table F11

*Chi-Square Tests for Extroversion-Introversion*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 11.84[a] | 9 | .22 |
| Likelihood Ratio | 11.94 | 9 | .23 |
| Linear-by-Linear Association | .94 | 1 | .33 |
| *N* of valid cases | 3,942 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 137.74.

Table F12

*Descriptive Statistics for LEP CCI Scores for 1993 - 1996 & 2002*

| Cohort | *N* | *M* | *SD* | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 1993 | 364 | 351.80 | 40.51 | 227 | 458 | 231 |
| 1994 | 337 | 344.11 | 44.23 | 210 | 442 | 232 |
| 1995 | 403 | 336.13 | 41.34 | 200 | 433 | 233 |
| 1996 | 297 | 335.91 | 45.93 | 210 | 439 | 229 |
| 2002 | 410 | 332.73 | 48.82 | 220 | 440 | 220 |
| Total | 1,811 | 339.96 | 44.77 | 200 | 458 | 258 |

Table F13

*ANOVA Summary for LEP CCI Scores*

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Between groups | 4 | 22,255.55 | 11.36*** | .00 |
| Within groups | 1,806 | 1,959.53 | | |
| Total | 1,810 | | | |

***$p < .001$.

Table F14

*Levine's Test for LEP CCI Scores*

| Levene statistic | *df1* | *df2* | *p* |
|---|---|---|---|
| 6.05*** | 4 | 1,806 | .00 |

***$p < .001$.

Table F15

*Games-Howell Analyses for LEP CCI Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1993 | 1993 | - | - | - |
| | 1994 | 7.68 | 3.21 | .12 |
| | 1995 | 15.67*** | 2.96 | .00 |
| | 1996 | 15.89*** | 3.41 | .00 |
| | 2002 | 19.06*** | 3.21 | .00 |
| 1994 | 1993 | -7.68 | 3.21 | .12 |
| | 1994 | - | - | - |
| | 1995 | 7.99 | 3.17 | .09 |
| | 1996 | 8.21 | 3.59 | .15 |
| | 2002 | 11.38** | 3.41 | .01 |
| 1995 | 1993 | -15.67*** | 2.96 | .00 |
| | 1994 | -7.99 | 3.17 | .09 |
| | 1995 | - | - | - |
| | 1996 | 0.22 | 3.37 | 1.00 |
| | 2002 | 3.39 | 3.17 | .82 |

Table F15 (Continued)

*Games-Howell Analyses for LEP CCI Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1996 | 1993 | -15.89*** | 3.41 | .00 |
| | 1994 | -8.21 | 3.59 | .15 |
| | 1995 | -0.22 | 3.37 | 1.00 |
| | 1996 | - | - | - |
| | 2002 | 3.17 | 3.59 | .90 |
| 2002 | 1993 | -19.06*** | 3.21 | .00 |
| | 1994 | -11.38** | 3.41 | .01 |
| | 1995 | -3.39 | 3.17 | .82 |
| | 1996 | -3.17 | 3.59 | .90 |
| | 2002 | - | - | - |

**$p < .01$. ***$p < .001$.

Table F16

*Descriptive Statistics for 1995 and 2002 CCI Sample*

| Cohort | *M* | *SD* | *N* |
|---|---|---|---|
| 1995 | 334.06 | 39.55 | 148 |
| 2002 | 334.82 | 48.76 | 148 |
| Total | 334.44 | 44.32 | 296 |

Table F17

*ANOVA Summary Table for 1995 & 2002 CCI Scores*

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| | | Between subjects | | |
| Gender | 1 | .00 | .00 | 1.00 |
| LEP CCI score | 1 | 43.14 | .02 | .88 |
| | | Within subjects | | |
| Gender | 294 | 0.25 | | |
| LEP CCI score | 294 | 1,970.80 | | |

Table F18

*Descriptive Analyses for SAT Verbal Scores*

| Cohort | *N* | *M* | *SD* | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 1993 | 374 | 540.64 | 76.03 | 330 | 780 | 450 |
| 1994 | 343 | 534.20 | 74.15 | 380 | 770 | 390 |
| 1995 | 461 | 569.48 | 89.97 | 290 | 800 | 510 |
| 1996 | 385 | 628.26 | 85.21 | 410 | 800 | 390 |
| 1997 | 384 | 636.82 | 76.71 | 430 | 800 | 370 |
| 1998 | 428 | 637.78 | 80.88 | 290 | 800 | 510 |
| 1999 | 391 | 642.79 | 79.08 | 480 | 800 | 320 |
| 2000 | 431 | 612.58 | 73.01 | 420 | 800 | 380 |
| 2001 | 405 | 615.43 | 71.89 | 350 | 800 | 450 |
| 2002 | 451 | 625.96 | 75.05 | 440 | 800 | 360 |
| Total | 4,053 | 605.54 | 87.01 | 290 | 800 | 510 |

Table F19

*ANOVA Summary for SAT Verbal Scores*

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Between groups | 9 | 636,806.06 | 103.20*** | .00 |
| Within groups | 4,043 | 6,170.52 | | |
| Total | 4,052 | | | |

***$p < .001$.

Table F20

*Levine's Test for SAT Verbal Scores*

| Levene statistic | *df1* | *df2* | *p* |
|---|---|---|---|
| 5.06*** | 9 | 4,043 | .00 |

***$p < .001$.

Table F21

*Games-Howell Analyses for SAT Verbal Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1993 | 1993 | - | - | - |
| | 1994 | 6.44 | 5.61 | .98 |
| | 1995 | -28.84*** | 5.75 | .00 |
| | 1996 | -87.62*** | 5.86 | .00 |
| | 1997 | -96.18*** | 5.55 | .00 |
| | 1998 | -97.14*** | 5.55 | .00 |
| | 1999 | -102.15*** | 5.61 | .00 |
| | 2000 | -71.94*** | 5.28 | .00 |
| | 2001 | -74.79*** | 5.31 | .00 |
| | 2002 | -85.31*** | 5.29 | .00 |
| 1994 | 1993 | -6.44 | 5.61 | .98 |
| | 1994 | - | - | - |
| | 1995 | -35.28*** | 5.80 | .00 |
| | 1996 | -94.06*** | 5.91 | .00 |
| | 1997 | -102.62*** | 5.60 | .00 |
| | 1998 | -103.58*** | 5.60 | .00 |
| | 1999 | -108.59*** | 5.66 | .00 |

Table F21 (Continued)

*Games-Howell Analyses for SAT Verbal Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1994 | 2000 | -78.38*** | 5.33 | .00 |
| | 2001 | -81.23*** | 5.37 | .00 |
| | 2002 | -91.76*** | 5.34 | .00 |
| 1995 | 1993 | 28.84*** | 5.75 | .00 |
| | 1994 | 35.28*** | 5.80 | .00 |
| | 1995 | - | - | - |
| | 1996 | -58.78*** | 6.03 | .00 |
| | 1997 | -67.34*** | 5.73 | .00 |
| | 1998 | -68.30*** | 5.73 | .00 |
| | 1999 | -73.31*** | 5.79 | .00 |
| | 2000 | -43.10*** | 5.47 | .00 |
| | 2001 | -45.95*** | 5.51 | .00 |
| | 2002 | -56.48*** | 5.48 | .00 |

Table F21 (Continued)

*Games-Howell Analyses for SAT Verbal Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1996 | 1993 | 87.62*** | 5.86 | .00 |
| | 1994 | 94.06*** | 5.91 | .00 |
| | 1995 | 58.78*** | 6.04 | .00 |
| | 1996 | - | - | - |
| | 1997 | -8.56 | 5.85 | .91 |
| | 1998 | -9.52 | 5.84 | .83 |
| | 1999 | -14.53 | 5.90 | .29 |
| | 2000 | 15.68 | 5.59 | .14 |
| | 2001 | 12.83 | 5.62 | .40 |
| | 2002 | 2.30 | 5.60 | 1.00 |
| 1997 | 1993 | 96.18*** | 5.55 | .00 |
| | 1994 | 102.62*** | 5.60 | .00 |
| | 1995 | 67.34*** | 5.73 | .00 |
| | 1996 | 8.56 | 5.85 | .91 |
| | 1997 | - | - | - |
| | 1998 | -.96 | 5.53 | 1.00 |
| | 1999 | -5.96 | 5.60 | .99 |

Table F21 (Continued)

*Games-Howell Analyses for SAT Verbal Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1997 | 2000 | 24.25*** | 5.26 | .00 |
| | 2001 | 21.39** | 5.30 | .002 |
| | 2002 | 10.87 | 5.27 | .56 |
| 1998 | 1993 | 97.14*** | 5.55 | .00 |
| | 1994 | 103.58*** | 5.60 | .00 |
| | 1995 | 68.30*** | 5.73 | .00 |
| | 1996 | 9.52 | 5.84 | .83 |
| | 1997 | 0.96 | 5.53 | 1.00 |
| | 1998 | - | - | - |
| | 1999 | -5.01 | 5.59 | 1.00 |
| | 2000 | 25.20*** | 5.26 | .00 |
| | 2001 | 22.35*** | 5.30 | .00 |
| | 2002 | 11.82 | 5.27 | .43 |
| 1999 | 1993 | 102.15*** | 5.61 | .00 |
| | 1994 | 108.59*** | 5.66 | .00 |
| | 1995 | 73.31*** | 5.79 | .00 |
| | 1996 | 14.53 | 5.90 | .29 |

Table F21 (Continued)

*Games-Howell Analyses for SAT Verbal Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *P* |
|---|---|---|---|---|
| 1999 | 1997 | 5.96 | 5.60 | .99 |
| | 1998 | 5.01 | 5.59 | 1.00 |
| | 1999 | - | - | - |
| | 2000 | 30.21*** | 5.33 | .00 |
| | 2001 | 27.36*** | 5.36 | .00 |
| | 2002 | 16.83* | 5.34 | .05 |
| 2000 | 1993 | 71.94*** | 5.28 | .00 |
| | 1994 | 78.38*** | 5.33 | .00 |
| | 1995 | 43.10*** | 5.47 | .00 |
| | 1996 | -15.68 | 5.59 | .14 |
| | 1997 | -24.25*** | 5.26 | .00 |
| | 1998 | -25.20*** | 5.26 | .00 |
| | 1999 | -30.21*** | 5.33 | .00 |
| | 2000 | - | - | - |
| | 2001 | -2.85 | 5.01 | 1.00 |
| | 2002 | -13.38 | 4.99 | .18 |

Table F21 (Continued)

*Games-Howell Analyses for SAT Verbal Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 2001 | 1993 | 74.79*** | 5.31 | .00 |
| | 1994 | 81.23*** | 5.37 | .00 |
| | 1995 | 45.95*** | 5.51 | .00 |
| | 1996 | -12.83 | 5.62 | .40 |
| | 1997 | -21.39** | 5.30 | .002 |
| | 1998 | -22.35*** | 5.30 | .001 |
| | 1999 | -27.36*** | 5.36 | .00 |
| | 2000 | 2.85 | 5.01 | 1.00 |
| | 2001 | - | - | - |
| | 2002 | -10.52 | 5.03 | .53 |
| 2002 | 1993 | 85.31*** | 5.29 | .00 |
| | 1994 | 91.76*** | 5.34 | .00 |
| | 1995 | 56.48*** | 5.48 | .00 |
| | 1996 | -2.30 | 5.60 | 1.00 |
| | 1997 | -10.87 | 5.27 | .56 |
| | 1998 | -11.82 | 5.27 | .43 |
| | 1999 | -16.83 | 5.34 | .05 |

Table F21 (Continued)

*Games-Howell Analyses for SAT Verbal Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 2002 | 2000 | 13.38 | 4.99 | .18 |
| | 2001 | 10.52 | 5.03 | .53 |
| | 2002 | - | - | - |

*$p$ < .05. **$p$ < .01. ***$p$ < .001.

Table F22

*Descriptive Analyses for SAT Quantitative Scores*

| | *N* | *M* | *SD* | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 1993 | 374 | 662.75 | 67.19 | 540 | 800 | 260 |
| 1994 | 343 | 658.19 | 64.20 | 540 | 800 | 260 |
| 1995 | 461 | 687.94 | 58.00 | 550 | 800 | 250 |
| 1996 | 385 | 682.65 | 63.49 | 540 | 800 | 260 |
| 1997 | 384 | 691.54 | 62.12 | 540 | 800 | 260 |
| 1998 | 428 | 696.96 | 63.11 | 510 | 800 | 290 |
| 1999 | 393 | 697.86 | 63.28 | 540 | 800 | 260 |
| 2000 | 431 | 669.93 | 67.68 | 480 | 800 | 320 |
| 2001 | 405 | 681.60 | 65.03 | 490 | 800 | 310 |
| 2002 | 451 | 682.37 | 61.00 | 500 | 800 | 300 |
| Total | 4,055 | 681.69 | 64.63 | 480 | 800 | 320 |

Table F23

*ANOVA Summary for SAT Quantitative Scores*

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Between groups | 9 | 71,279.34 | 17.70 | .00 |
| Within groups | 4,045 | 4,027.08 | | |
| Total | 4,054 | | | |

***$p < .001$.

Table F24

*Levine's Test for SAT Quantitative Scores*

| Levene statistic | *df1* | *df2* | *p* |
|---|---|---|---|
| 1.93* | 9 | 4,045 | .04 |

$^{*}p < .05$.

Table F25

*Games-Howell Analyses for SAT Quantitative Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1993 | 1993 | - | - | - |
| | 1994 | 4.56 | 4.91 | 1.00 |
| | 1995 | -25.19*** | 4.40 | .00 |
| | 1996 | -19.90** | 4.75 | .00 |
| | 1997 | -28.78*** | 4.70 | .00 |
| | 1998 | -34.21*** | 4.62 | .00 |
| | 1999 | -35.11*** | 4.72 | .00 |
| | 2000 | -7.18 | 4.76 | .89 |
| | 2001 | -18.85** | 4.75 | .00 |
| | 2002 | -19.62*** | 4.51 | .00 |
| 1994 | 1993 | -4.56 | 4.91 | 1.00 |
| | 1994 | - | - | - |
| | 1995 | -29.75 | 4.40 | .00*** |
| | 1996 | -24.46 | 4.74 | .00*** |
| | 1997 | -33.34 | 4.70 | .00*** |
| | 1998 | -38.77 | 4.62 | .00*** |
| | 1999 | -39.67 | 4.71 | .00*** |

Table F25 (Continued)

*Games-Howell Analyses for SAT Quantitative Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1994 | 2000 | -11.74 | 4.76 | .29 |
| | 2001 | -23.41 | 4.74 | .00*** |
| | 2002 | -24.18 | 4.50 | .00*** |
| 1995 | 1993 | 25.19*** | 4.40 | .00 |
| | 1994 | 29.75*** | 4.40 | .00 |
| | 1995 | - | - | - |
| | 1996 | 5.29 | 4.22 | .96 |
| | 1997 | -3.60 | 4.17 | 1.00 |
| | 1998 | -9.02 | 4.08 | .45 |
| | 1999 | -9.92 | 4.18 | .34 |
| | 2000 | 18.01* | 4.23 | .00 |
| | 2001 | 6.33 | 4.21 | .89 |
| | 2002 | 5.57 | 3.94 | .92 |
| 1996 | 1993 | 19.90*** | 4.75 | .00 |
| | 1994 | 24.46*** | 4.74 | .00 |
| | 1995 | -5.29 | 4.22 | .96 |
| | 1996 | - | - | - |

Table F25 (Continued)

*Games-Howell Analyses for SAT Quantitative Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1996 | 1997 | -8.89 | 4.53 | .63 |
| | 1998 | -14.31* | 4.45 | .04 |
| | 1999 | -15.21* | 4.55 | .03 |
| | 2000 | 12.72 | 4.60 | .15 |
| | 2001 | 1.04 | 4.57 | 1.00 |
| | 2002 | 0.28 | 4.33 | 1.00 |
| 1997 | 1993 | 28.78*** | 4.70 | .00 |
| | 1994 | 33.34*** | 4.70 | .00 |
| | 1995 | 3.60 | 4.17 | 1.00 |
| | 1996 | 8.89 | 4.53 | .63 |
| | 1997 | - | - | - |
| | 1998 | -5.43 | 4.40 | .97 |
| | 1999 | -6.33 | 4.50 | .93 |
| | 2000 | 21.61*** | 4.55 | .00 |
| | 2001 | 9.93 | 4.53 | .46 |
| | 2002 | 9.16 | 4.28 | .50 |

Table F25 (Continued)

*Games-Howell Analyses for SAT Quantitative Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1998 | 1993 | 34.21*** | 4.62 | .00 |
| | 1994 | 38.77*** | 4.62 | .00 |
| | 1995 | 9.02 | 4.08 | .45 |
| | 1996 | 14.31* | 4.45 | .04 |
| | 1997 | 5.43 | 4.40 | .97 |
| | 1998 | - | - | - |
| | 1999 | -0.90 | 4.42 | 1.00 |
| | 2000 | 27.03*** | 4.47 | .00 |
| | 2001 | 15.36** | 4.44 | .02 |
| | 2002 | 14.59** | 4.19 | .02 |
| 1999 | 1993 | 35.11*** | 4.72 | .00 |
| | 1994 | 39.67*** | 4.71 | .00 |
| | 1995 | 9.92 | 4.18 | .34 |
| | 1996 | 15.21* | 4.55 | .03 |
| | 1997 | 6.33 | 4.50 | .93 |
| | 1998 | 0.90 | 4.42 | 1.00 |
| | 1999 | - | - | - |

Table F25 (Continued)

*Games-Howell Analyses for SAT Quantitative Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1999 | 2000 | 27.93*** | 4.56 | .00 |
| | 2001 | 16.26** | 4.54 | .01 |
| | 2002 | 15.49** | 4.29 | .01 |
| 2000 | 1993 | 7.18 | 4.76 | .89 |
| | 1994 | 11.74 | 4.76 | .29 |
| | 1995 | -18.01*** | 4.23 | .00 |
| | 1996 | -12.72 | 4.59 | .15 |
| | 1997 | -21.61*** | 4.55 | .00 |
| | 1998 | -27.03*** | 4.47 | .00 |
| | 1999 | -27.93*** | 4.56 | .00 |
| | 2000 | - | - | - |
| | 2001 | -11.67 | 4.59 | .25 |
| | 2002 | -12.44 | 4.35 | .12 |
| 2001 | 1993 | 18.85*** | 4.75 | .00 |
| | 1994 | 23.41*** | 4.74 | .00 |
| | 1995 | -6.33 | 4.21 | .89 |
| | 1996 | -1.04 | 4.57 | 1.00 |

Table F25 (Continued)

*Games-Howell Analyses for SAT Quantitative Scores*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 2001 | 1997 | -9.93 | 4.53 | .46 |
| | 1998 | -15.36* | 4.44 | .02 |
| | 1999 | -16.26** | 4.54 | .01 |
| | 2000 | 11.67 | 4.59 | .25 |
| | 2001 | - | - | - |
| | 2002 | -0.77 | 4.32 | 1.00 |
| 2002 | 1993 | 19.62*** | 4.51 | .00 |
| | 1994 | 24.18*** | 4.50 | .00 |
| | 1995 | -5.57 | 3.94 | .92 |
| | 1996 | -0.28 | 4.33 | 1.00 |
| | 1997 | -9.16 | 4.28 | .50 |
| | 1998 | -14.59* | 4.19 | .02 |
| | 1999 | -15.49** | 4.29 | .01 |
| | 2000 | 12.44 | 4.35 | .12 |
| | 2001 | 0.77 | 4.32 | 1.00 |
| | 2002 | - | - | - |

*$p < .05$. **$p < .01$. ***$p < .001$.

Table F26

*Correlations between SAT Scores and CCI Scores*

| Cohort | *N* | SAT verbal scores | SAT math scores |
|---|---|---|---|
| 1993 | 373 | .33 | .19 |
| 1994 | 344 | .24 | .14 |
| 1995 | 462 | .10 | .03* |
| 1996 | 382 | .17 | .23 |
| 2002 | 452 | .17 | .15 |
| Total | 2,013 | | |

*$p < .05$.

Table F27

*Descriptive Analyses for Age*

| Cohort | *N* | *M* | *SD* | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 1993 | 373 | 18.24 | 0.48 | 17 | 19 | 2 |
| 1994 | 344 | 18.31 | 0.55 | 17 | 22 | 5 |
| 1995 | 462 | 18.27 | 0.51 | 16 | 21 | 5 |
| 1996 | 382 | 18.37 | 0.51 | 17 | 20 | 3 |
| 1997 | 384 | 18.36 | 0.69 | 16 | 24 | 8 |
| 1998 | 427 | 18.33 | 0.52 | 17 | 22 | 5 |
| 1999 | 395 | 18.59 | 1.33 | 17 | 25 | 8 |
| 2000 | 436 | 18.38 | 0.53 | 16 | 20 | 4 |
| 2001 | 405 | 18.40 | 0.52 | 17 | 20 | 3 |
| 2002 | 452 | 18.40 | 0.57 | 16 | 22 | 6 |
| Total | 4,060 | 18.37 | 0.67 | 16 | 25 | 9 |

Table F28

*ANOVA Summary for Age*

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Between groups | 9 | 3.63 | 8.26 | .00 |
| Within groups | 4,050 | 0.44 | | |
| Total | 4,059 | | | |

***$p < .001$.

Table F29

*Games-Howell Analyses for Age*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1993 | 1993 | - | - | - |
| | 1994 | -0.07 | 0.04 | .69 |
| | 1995 | -0.02 | 0.04 | 1.00 |
| | 1996 | -0.13** | 0.04 | .01 |
| | 1997 | -0.12 | 0.04 | .17 |
| | 1998 | -0.09 | 0.04 | .27 |
| | 1999 | -0.35*** | 0.07 | .00 |
| | 2000 | -0.14*** | 0.04 | .00 |
| | 2001 | -0.16*** | 0.04 | .00 |
| | 2002 | -0.16*** | 0.04 | .00 |
| 1994 | 1993 | 0.07 | 0.04 | .69 |
| | 1994 | - | - | - |
| | 1995 | 0.05 | 0.04 | .96 |
| | 1996 | -0.06 | 0.04 | .91 |
| | 1997 | -0.05 | 0.05 | .99 |
| | 1998 | -0.02 | 0.04 | 1.00 |
| | 1999 | -0.28** | 0.07 | .01 |

Table F29 (Continued)

*Games-Howell Analyses for Age*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1994 | 2000 | -0.07 | 0.04 | .79 |
| | 2001 | -0.08 | 0.04 | .51 |
| | 2002 | -0.08 | 0.04 | .52 |
| 1995 | 1993 | 0.02 | 0.03 | 1.00 |
| | 1994 | -0.05 | 0.04 | .96 |
| | 1995 | - | - | - |
| | 1996 | -0.11 | 0.04 | .08 |
| | 1997 | -0.09 | 0.04 | .47 |
| | 1998 | -0.06 | 0.04 | .71 |
| | 1999 | -0.32*** | 0.07 | .00 |
| | 2000 | -0.11* | 0.04 | .04 |
| | 2001 | -0.13** | 0.04 | .01 |
| | 2002 | -0.13** | 0.04 | .01 |
| 1996 | 1993 | 0.13* | 0.04 | .01 |
| | 1994 | 0.06 | 0.04 | .91 |
| | 1995 | 0.11 | 0.04 | .08 |
| | 1996 | - | - | - |

Table F29 (Continued)

*Games-Howell Analyses for Age*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1996 | 1997 | 0.01 | 0.04 | 1.00 |
| | 1998 | 0.04 | 0.04 | .98 |
| | 1999 | -0.22 | 0.07 | .07 |
| | 2000 | -0.01 | 0.04 | 1.00 |
| | 2001 | -0.03 | 0.04 | 1.00 |
| | 2002 | -0.03 | 0.04 | 1.00 |
| 1997 | 1993 | 0.12 | 0.04 | .17 |
| | 1994 | 0.05 | 0.05 | .99 |
| | 1995 | 0.09 | 0.04 | .47 |
| | 1996 | -0.01 | 0.04 | 1.00 |
| | 1997 | - | - | - |
| | 1998 | 0.03 | 0.04 | 1.00 |
| | 1999 | -0.23 | 0.08 | .07 |
| | 2000 | -0.02 | 0.04 | 1.00 |
| | 2001 | -0.04 | 0.04 | 1.00 |
| | 2002 | -0.04 | 0.04 | 1.00 |

Table F29 (Continued)

*Games-Howell Analyses for Age*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1998 | 1993 | 0.09 | 0.04 | .27 |
| | 1994 | 0.02 | 0.04 | 1.00 |
| | 1995 | 0.06 | 0.04 | .71 |
| | 1996 | -0.04 | 0.04 | .96 |
| | 1997 | -0.03 | 0.04 | 1.00 |
| | 1998 | - | - | - |
| | 1999 | -0.26* | 0.07 | .01 |
| | 2000 | -0.05 | 0.04 | .93 |
| | 2001 | -0.07 | 0.04 | .70 |
| | 2002 | -0.07 | 0.04 | .71 |
| 1999 | 1993 | 0.35* | 0.07 | .00 |
| | 1994 | 0.28* | 0.07 | .01 |
| | 1995 | 0.32* | 0.07 | .00 |
| | 1996 | 0.22 | 0.07 | .07 |
| | 1997 | 0.23 | 0.08 | .07 |
| | 1998 | 0.26* | 0.07 | .01 |
| | 1999 | - | - | - |

Table F29 (Continued)

*Games-Howell Analyses for Age*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 1999 | 2000 | 0.21 | 0.07 | .10 |
| | 2001 | 0.19 | 0.07 | .18 |
| | 2002 | 0.19 | 0.07 | .19 |
| 2000 | 1993 | 0.14* | 0.04 | .00 |
| | 1994 | 0.07 | 0.04 | .79 |
| | 1995 | 0.11* | 0.04 | .03 |
| | 1996 | 0.01 | 0.04 | 1.00 |
| | 1997 | 0.02 | 0.04 | 1.00 |
| | 1998 | 0.05 | 0.04 | .93 |
| | 1999 | -0.21 | 0.07 | .10 |
| | 2000 | - | - | - |
| | 2001 | -0.02 | 0.04 | 1.00 |
| | 2002 | -0.02 | 0.04 | 1.00 |
| 2001 | 1993 | 0.16* | 0.04 | .00 |
| | 1994 | 0.08 | 0.04 | .51 |
| | 1995 | 0.13* | 0.04 | .01 |
| | 1996 | 0.03 | 0.04 | 1.00 |

Table F29 (Continued)

*Games-Howell Analyses for Age*

| (I) Cohort | (J) Cohort | (I-J) Mean difference | *SE* | *p* |
|---|---|---|---|---|
| 2001 | 1997 | 0.04 | 0.04 | 1.00 |
| | 1998 | 0.07 | 0.04 | .69 |
| | 1999 | -0.19 | 0.07 | .18 |
| | 2000 | 0.02 | 0.04 | 1.00 |
| | 2001 | - | - | - |
| | 2002 | 0.00 | 0.04 | 1.00 |
| 2002 | 1993 | 0.16* | 0.04 | .00 |
| | 1994 | 0.08 | 0.04 | .52 |
| | 1995 | 0.13* | 0.04 | .01 |
| | 1996 | 0.03 | 0.04 | 1.00 |
| | 1997 | 0.04 | 0.04 | 1.00 |
| | 1998 | 0.07 | 0.04 | .71 |
| | 1999 | -0.19 | 0.07 | .19 |
| | 2000 | 0.02 | 0.04 | 1.00 |
| | 2001 | 0.00 | 0.04 | 1.00 |
| | 2002 | - | - | - |

*p < *.05*. **p < *.01*. ***p < *.001.*

Table F30

*Frequency Counts of Parental Education*

| Cohort | Both parents college graduates | Father college graduate | Mother college graduate | First generation college student | Total |
|---|---|---|---|---|---|
| 1993 | 127 | 69 | 44 | 135 | 375 |
| 1994 | 120 | 59 | 40 | 127 | 346 |
| 1995 | 166 | 75 | 59 | 163 | 463 |
| 1996 | 145 | 61 | 47 | 132 | 385 |
| 1997 | 130 | 78 | 49 | 128 | 385 |
| 1998 | 171 | 76 | 41 | 140 | 428 |
| 1999 | 150 | 66 | 57 | 122 | 395 |
| 2000 | 171 | 60 | 44 | 161 | 436 |
| 2001 | 190 | 56 | 37 | 122 | 405 |
| 2002 | 208 | 57 | 54 | 133 | 452 |
| Total | 1,578 | 657 | 472 | 1,363 | 4,070 |

Table F31

*Chi-Square Tests for Parental Education*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 49.91 [a] ** | 27 | .01 |
| Likelihood Ratio | 49.60** | 27 | .01 |
| Linear-by-Linear Association | 15.37*** | 1 | .00 |
| *N* of valid cases | 4,070 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 40.13.

** $p < .01$. *** $p < .001$.

Table F32

*Chi-Square Directional Measures for Parental Education*

| | Value | *SE* | *p* |
|---|---|---|---|
| Lambda | | | |
| Symmetric | .01 | 0.01 | .06 |
| Cohort dependent | .01* | 0.01 | .05 |
| Parental education dependent | .01 | 0.01 | .51 |
| Goodman and Kruskal tau | | | |
| Cohort dependent | .00*** | 0.00 | .00 |
| Parental education dependent | .01*** | 0.00 | .00 |
| Uncertainty Coefficient | | | |
| Cohort dependent | .00** | 0.00 | .01 |
| Parental education dependent | .01** | 0.00 | .01 |

*p < *.05*. **p < *.01*. ***p < *.001*.

Table F33

*Frequency Counts for Gender for 1995 through 2002*

| Gender | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|
| Male | 383 | 312 | 313 | 362 | 338 | 365 | 312 | 372 |
| Female | 80 | 73 | 72 | 66 | 57 | 71 | 93 | 80 |
| Total | 463 | 385 | 385 | 428 | 395 | 436 | 405 | 452 |

Table F34

*Chi-Square Statistics for Gender 1995 through 2002*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 13.48 [a] | 7 | .06 |
| Likelihood Ratio | 13.16 | 7 | .07 |
| Linear-by-Linear Association | .37 | 1 | .54 |
| *N* of valid cases | 3,349 | | |

*Note.* [a] 0 cells (0%) have expected count less than 5.

The minimum expected count is 68.06.

Table F35

*Frequency Counts for Ethnicity across Cohorts*

| Ethnicity | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Caucasian | 354 | 327 | 432 | 369 | 355 | 405 | 374 | 409 | 376 | 417 |
| Asian | 12 | 9 | 12 | 5 | 15 | 11 | 9 | 9 | 12 | 15 |
| Hispanic | 3 | 4 | 6 | 3 | 3 | 2 | 2 | 4 | 9 | 6 |
| African-American | 4 | 4 | 5 | 5 | 6 | 7 | 4 | 7 | 4 | 12 |
| International | 1 | 0 | 7 | 2 | 4 | 3 | 5 | 7 | 3 | 2 |
| American Indian | 0 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 1 | 0 |
| Total | 374 | 346 | 463 | 385 | 385 | 428 | 395 | 436 | 405 | 452 |

Table F36

*Chi-Square Statistics for Ethnicity*

| | Value | *df* | *p* |
|---|---|---|---|
| Pearson Chi-Square | 44.54 [a] | 45 | .49 |
| Continuity Correction | | | |
| Likelihood Ratio | 47.48 | 45 | .37 |
| Linear-by-Linear Association | 2.10 | 1 | .15 |
| *N* of valid cases | 4,069 | | |

*Note.* [a] 31 cells (51.7%) have expected count less than 5.

The minimum expected count is .68.

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