Int. J. Engng Ed. Vol. 14, No. 5, pp. 311–315, 1998
Printed in Great Britain.
0949-149X/91 $3.00+0.00

Myers-Briggs Type Indicator and Academic Achievement in Engineering Education*

TERRANCE P. O'BRIEN, LEONHARD E. BERNOLD and DUANE AKROYD
North Carolina State University, Raleigh, NC 27695-7801, USA. E-mail: terry@poe.coe.ncsu.edu

The study reported here was conducted to investigate patterns of psychological types among students in a lower division engineering course and differences in the academic performance of those students associated with differences in psychological type. The Myers-Briggs Type Indicator was administered to 83 undergraduate engineering students enrolled in CE 214 Engineering Mechanics Statics at North Carolina State University. Analysis of variance was used to explore differences in numeric end-of-course grades of the students in relation to their different personality types. One of the most interesting findings was that students exhibiting the Intuitive type had significantly higher grades in the course than students preferring the Sensing type.

INTRODUCTION

IN RECENT YEARS, engineering faculty at colleges and universities across the country have been challenged by the National Science Board, the National Science Foundation, the Accreditation Board for Engineering and Technology, and society to change the curriculum and instructional methods in engineering education to align more closely with the qualifications which are expected to be required of future graduates. Responding to this national movement for quality engineering education, a group of universities in the southern United States established a National Science Foundation sponsored program referred to as the Southeastern University and College Coalition for Engineering Education (SUCCEED). Since 1993, faculty at North Carolina State University (NCSU) have conducted a variety of research projects sponsored by SUCCEED involving the design and evaluation of innovative, holistic approaches to engineering education.

Much of the research and development at NCSU has focused on the implementation of holistic teaching and learning in CE 214 Engineering Mechanics Statics. A fundamental tenet of this holistic approach is that personal experience and active learning more effectively stimulate cognitive processing than do more traditional forms of passive learning. Some examples of the types of experiences students are exposed to in this approach include hands-on model building, active experimentation, experience-based learning, co-operative learning, team-games tournaments, and reinforcement of classroom learning through integrated experiences at actual construction sites. The experiences are deliberately designed to accommodate a variety of personality traits and learning styles among students in the course. The goal is to enable a more diverse student population to be more successful in their engineering education.

THEORETICAL FRAMEWORK

Learning styles

The concept of learning styles has received considerable attention among teachers and researchers in many schools, colleges, and universities. The term 'learning styles' has been defined as 'cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment' [1, p. 44]. Claxton and Murrell [2] published an overview of theory and research in the field of learning styles and discussed significant implications for educational practice. They analyzed learning styles at four levels: personality, information processing, social interaction, and instructional methods. After reviewing the state of the art of research in learning styles, the authors indicated a need for further investigation in a number of areas. They reported that we need to know more about the actual impact on learning when methods used by an instructor are inconsistent with a student's style. They also called for additional research addressing interactions between learning style, developmental stage, disciplinary perspectives, and epistemology. Research in these areas might offer educators a better understanding of teaching and learning processes, as well as insights which would enable them to enhance instructional effectiveness.

While the construct we refer to as learning styles includes cognitive, affective, and physiological dimensions, cognitive styles appear to hold the greatest potential for yielding new understandings relevant to the educational process. The term

* Accepted 10 September 1998.

cognitive styles has been defined as 'information processing habits representing the learner's typical mode of perceiving, thinking, problem solving, and remembering' [3, p. 188]. Although the design of motivational strategies and the manipulation of environmental factors may indeed enhance learning, human cognition is at the core of the learning process. Cognitive styles involve both cognitive perception and processing (ordering, evaluating, structuring, etc.). Dimensions of cognitive style appear to be most relevant to variables associated with academic achievement or mental ability, especially when such constructs are assessed by tests and other means of standardized instrumentation.

Psychological types

The theory of psychological types advanced by C. G. Jung [4] and operationalized by I. B. Myers and K. C. Briggs, through the development of the Myers-Briggs Type Indicator (MBTI), provided another dimension of the theoretical framework and research base for the study. Fundamentally, the premise of the theory is 'that much seemingly random variation in behavior is actually quite orderly and consistent, being due to basic differences in the way individuals prefer to use their perception and judgment' [5, p. 1]. Perception is a construct associated with the ways in which one becomes aware of ideas, persons, things, and events in his or her environment. Judgment is a construct related to how one draws conclusions about what he or she has perceived. Jung's theory posits that systematic variation in perception and judgment among individuals would create variation in their interests, values, motivations, skills, and reactions. The constructs of perception and judgment are inherently cognitive in nature.

The MBTI was developed to implement Jung's theory so that it could be applied and examined empirically. Currently, the MBTI is one of the most widely utilized instruments for measuring personality differences. It has been used for many different purposes including self-development, career development and exploration, relationship counseling, academic counseling, organizational development, team building, problem solving, management and leadership training, education and curriculum development, and diversity and multicultural training [6]. The MBTI has also been used in many studies of different aspects of professional education, including research specific to the profession of engineering [7–11].

The MBTI measures four separate preferences or 'indices', each of which is based on Jung's theories concerning perception and judgment. The preferences have implications for 'not only *what* people attend to in any given situation, but also *how* they draw conclusions about what they perceive' [5].

- *Extroversion-Introversion* (*EI*). This index assesses the extent to which an individual tends to be either an extrovert or an introvert. Extroverts tend to focus on external reality (the outer world) and direct their attention toward people and objects. By contrast, introverts attend more to internal reality (the inner world) and concentrate more on concepts and ideas.
- *Sensing-Intuition* (*SN*). The SN index directly measures an individual's preference in the area of cognitive perception. A person who relies more on sensing tends to rely on one or more of the five senses to interpret facts or events. Someone who relies more on intuition to assign meaning uses a more abstract, intuitive process, relying more on internal sources of information to interpret reality.
- *Thinking-Feeling* (*TF*). This index directly measures a person's preference in the area of judging. One may rely more on thinking to make decisions on the basis of objective, logical reasoning (T), or one may rely more on feeling (F) to make decisions more subjectively on the basis of internal or external value systems.
- *Judgment-Perception* (*JP*). This index assesses the process an individual uses predominantly in interacting with the 'outer world'. One individual may tend to prefer using a judgment process (J) when dealing with the external environment, while another may tend to prefer using a perceptive process (P).

Preferences on the four indices produce sixteen possible combinations which are referred to as 'types' or styles. An individual's type or style is indicated by the four letters of the preferences (e.g. ESTF, INFP). The theory suggests that each of the sixteen types has an associated set of preferred processes and attitudes which tend to be utilized more frequently and effectively by persons of that type. Detailed descriptions of the type profiles can be found in *Introduction to Type* [6] and *Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator* [5].

While the MBTI is a more comprehensive instrument in that it purports to measure 'personality', it clearly measures a number of constructs which relate to the concept of learning styles. Several dimensions measured by the MBTI are cognitive in nature and have implications for research in cognitive styles (i.e., Sensing-Intuition).

MBTI and research in engineering education

McCaulley [7] reported the results of a two-year study of 3718 students from eight engineering schools and their performance on the MBTI. Among their findings was the observation that engineering students demonstrated dramatic preferences for Thinking (74%) and Judging (61%). The four TJ types accounted for almost half of their sample. They also reported that males appeared to be slightly more Introverted (56%) and that the sample was fairly evenly divided between Sensing types (53%) and Intuitive types

(47%). When they examined the distribution of personality types across the different engineering disciplines, they identified a number of interesting patterns. The most robust pattern concerned the SN dimension of the MBTI. The engineering disciplines with the highest proportion of the Sensing types were civil (69%), industrial (61%), mechanical (61%), and mining (60%). The Intuitive types were prominent in physics (63%), geological (62%), aerospace (60%). and metallurgical (54%).

When researchers examined MBTI data from the same group of engineering schools three years later [8], results confirmed their earlier findings pertaining to the prominence of Thinking types and Judging types among engineering students. They also reported balanced distributions of Sensing and Intuitive types in the data set. They noted, however, that a concurrent examination of students in engineering schools in a MBTI data bank maintained by the Center for Applications of Psychological Type revealed more subtle differences associated with this dimension. In the latter samples, engineering schools which possessed 'high prestige' were populated by students of the Intuitive type (approximately two-thirds). 'At all levels of education from eighth grade to medical school . . . schools with higher average scores on scholastic aptitude tests also had higher percentages of Intuitive types' [8, p. 103].

PURPOSE OF THE STUDY

The purpose of the study was to investigate patterns in psychological type among students in a lower division engineering course and differences in the academic performance of those students associated with differences in psychological types. The course selected for examination was CE 214 Engineering Mechanics Statics. CE 214 is required of all students in the College of Engineering at North Carolina State University and is well known for: (a) the rigorous nature of the course curriculum, and (b) the wide variation of student performance in the course. Impetus for the study evolved from concerns among engineering faculty regarding the latter factor. Since the curriculum for the course is considered by the faculty to be both appropriate and fixed, they initiated a collaborative effort with colleagues in the College of Education and Psychology to investigate the extent to which variation in student achievement in the course might be associated with variables related to the realm of learning; specifically personality types or cognitive styles. Research questions posited by investigators in this study included:

1. What patterns of personality types were manifested among students enrolled in the lower division engineering course during the duration of the study?
2. How much variation in academic achievement was present among students enrolled in the lower division engineering course during the duration of the study?
3. Were significant differences in academic achievement among students in the engineering course associated with differences in the personality types or cognitive styles of students?

RESEARCH METHODOLOGY AND DATA SOURCES

The Myers-Briggs Type Indicator was administered to 83 undergraduate engineering students enrolled in a lower division introductory engineering course. Data were collected during two consecutive semesters. Demographic information was collected, as well as final numeric student grades in the course at the end of the semester. Basic descriptive statistics were utilized to assess data relevant to the first and second research questions; patterns in personality types, and variation in academic achievement. Analysis of variance (ANOVA) was employed to explore potential significant differences in academic achievement in the course related to differences in personality types or cognitive styles as determined by the MBTI. The preferred type on each of the four indices served as the independent variables, while numeric end-of-course grade functioned as the dependent variable in the analysis of variance.

RESULTS

Descriptive statistics revealed the following profile of psychological types among the 83 engineering students included in the study:

(a) 34 (41%) Extroversion, 49 (59%) Introversion;
(b) 60 (72%) Sensing-Perception, 23 (28%) Intuitive-Perception;
(c) 62 (75%) Thinking-Judgment, 21 (25%) Feeling-Judgment;
(d) 51 (61%) Judgment, 32, (39%) Perception.

Demographically, 16 (19%) students were female, 51 (62%) students were male, while 16 (19%) did not respond to this item.

Variance in academic achievement

In regard to academic achievement, end-of-course numeric grades ranged from 47.1 to 97.6 on a 100 point scale; a range of 50.5. This suggested a considerable amount of variance within the sample. The overall mean grade for the entire sample was 73.59 with a standard deviation of 15.66. The relatively large standard deviation was also an indicator that, indeed, there was a great deal of variation in student achievement in the course under study.

Psychological types and academic achievement

Table 1 presents the results of the ANOVA model tested in this investigation. No significant

Table 1. MBTI personality types and academic achievement in CE 214

Source	df	SS	F	p
Extroversion-Introversion	1	132.85	1.31	0.26
Thinking-Feeling	1	176.41	1.74	0.19
Sensing-Intuition	1	526.70	5.20	0.03
Judging-Perceiving	1	206.39	2.04	0.16

differences in academic achievement in CE 214 were manifested in relation to the dimensions of Extroversion-Introversion, Thinking-Feeling, or Judging-Perceiving. A significant main effect did emerge in relation to the Sensing-Intuition dimension, $F(1) = 5.20$, $p = 0.03$. Students with Intuitive personality types, or cognitive styles, achieved significantly higher end-of-course grades than students with Sensing styles. This finding was quite interesting, especially since only 23 (28%) of the students in the course indicated a preference for the Intuitive style of perception and cognitive processing. We also noted that significant effects associated with the Sensing-Intuition dimension did not emerge in McCaulley's earlier study [10].

DISCUSSION

A cursory examination of the findings revealed that in this sample of undergraduate engineering students, the ISTJ (Introversion, Sensing-Perception, Thinking-Judgment, Judgment) profile was quite prominent. Thinking and Judging were also predominant among a sample of engineering students in eight specialties studied by McCaulley [10], as well as in two earlier studies of engineering students [7, 8].

In her research, McCaulley also found a fairly balanced distribution between Sensing types and Intuitive types. The majority of the participants in this study, however, exhibited a preference for Sensing (72%) while only 23% preferred Intuition. Given the findings related to academic achievement, this pattern may hold significant implications for engineering education. If, for example, the actual distribution of students in Colleges of Engineering has changed substantially on this dimension since McCaulley's last study, engineering faculty are confronted with a very serious challenge to find ways of helping Sensing students learn more effectively. This possible shift should be confirmed by additional research, however, as this distribution may be only an artifact of a relatively small sample of 83 participants.

The large amount of variance in academic achievement among students in CE 214 suggests that in spite of faculty efforts to provide more varied, holistic approaches to teaching and learning in this course, more may be needed. This would appear to be particularly true in regard to students preferring the Sensing style. In this exploratory investigation, no attempts were made to utilize MBTI data in diagnostic and prescriptive ways. Perhaps a more systematic approach to analyzing the differing needs and preferences of Sensing and Intuitive students, and then providing them with different types of learning opportunities highly congruent with their respective styles would reduce the variance in achievement and help all students perform at a higher level in the course.

This concept is not new. Felder and Silverman [9] articulated the same idea in a slightly different way: 'The hypothesis . . . is that engineering instructors who adapt their teaching style to include both poles of each of the given dimensions should come close to providing an optimal learning environment for most (if not all) students in a class' [9, p. 675].

The findings in this investigation connect in interesting ways to findings in other studies of engineering students reported in the literature. Those connections begin to suggest important relationships between the construct of psychological type or cognitive style and other constructs such as tendency to major in engineering, effective and ineffective learning style patterns among students in engineering courses, and probability of successfully completing a college curriculum in engineering. The most significant contribution of this study to the literature is associated with the distribution of engineering students on the Sensing-Intuition dimension and concomitant variation in academic achievement in engineering education. It is especially interesting to note that this significant difference in academic achievement emerged among students in a course taught by faculty who were making concerted efforts to provide more holistic approaches to teaching and learning. Perhaps this implies something about the profound nature of individual differences on this dimension. This finding may also suggest something about the deeply engrained perceptions of faculty toward students who exhibit behaviors both similar to and quite different from their own. There are certainly many implications for future research in this area.

According to McCaulley, 'The Sensing-Intuition difference is by far the most important of the preferences in the research on the MBTI in education' [10, p. 538]. The Sensing mode of cognitive perception involves attending to concrete reality and focusing on things that are tangible, practical, and observable. Persons with a preference for this style exhibit a tendency to restrict their attention to matters with which they are immediately confronted and tend not to think a great deal about future circumstances and events. Intuitive thinkers, by contrast, are concerned with abstract concepts and theories. They exhibit imagination, a fondness for complexity, and a tendency to focus on the 'big picture'. Traditional approaches to teaching in colleges and universities involve reading, lecturing, writing, etc. All of these methods require students to think and process information intuitively. At all levels of education and on academic aptitude tests, intuitive students earn higher scores. These environments and instruments are simply not designed to address the practical intelligence of sensing students.

'Engineering has, and will continue to have, the challenge of engaging the interest . . . of those students whose minds work in a linear fashion (S) and of those whose minds concern themselves with patterns (N)' [8, p. 107]. Engineering appears to 'attract large numbers of hands-on practitioners and theoretical visionaries' [8, p. 107]. Neither style is inherently superior to the other. The issue is more a matter of recognizing that there are indeed 'multiple intelligences' in the sense that they are discussed by Howard Gardner [12]. Therefore, it is imperative that engineering faculty come to value, respect, and accommodate the learning needs and preferences of both types of students. Both types of thinkers are needed in the engineering profession. Engineering educators have a responsibility both to their students and their profession to respond in substantive and meaningful ways to research into the nature of individual differences.

REFERENCES

1. J. W. Keefe, Assessing student learning styles: an overview, in J. W. Keefe (ed.), *Student Learning Styles and Brain Behavior*, Reston, VA: National Association of Secondary School Principals (1982) pp. 43–53.
2. C. S. Claxton and P. H. Murrell, *Learning Styles: Implications for Improving Education Practices* (ASHE-ERIC Higher Education Report No. 4). Washington, DC: Association for the Study of Higher Education (1987).
3. S. Messick, The criterion problem in the evaluation of instruction: assessing possible, not just intended, outcomes, in W. C. Wittrock and D. E. Wiley (eds.), *The Evaluation of Instruction: Issues and Problems*, New York: Holt, Rinehart & Winston (1970) pp. 183–202.
4. C. G. Jung, *Psychological Types*, (H. G. Baynes, trans., revised R. F. C. Hull) Volume 6 of *The Collected Works of C. G. Jung*, Princeton, NJ: Princeton University Press (1971). (Original work published in 1921.)
5. I. B. Myers, and M. H. McCaulley, *Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator*, Palo Alto, CA: Consulting Psychologists Press (1985).
6. I. B. Myers, *Introduction to Type* (5th ed.), Palo Alto, CA: Consulting Psychologists Press (1993).
7. M. H. McCaulley, E. S. Godleski, C. F. Yokomoto, L. Harrisberger and E. D. Sloan, Applications of psychological type in engineering education, *Engineering Education*, **73**, 5, (1983) pp. 394–400.
8. M. H. McCaulley, G. P. Macdaid and R. Walsh, Myers-Briggs Type Indicator and retention in engineering, *Int. J. Applied Engineering*, **3**, 2, (1987), pp. 99–109.
9. R. M. Felder and L. K. Silverman, Learning and teaching styles in engineering education, *Engineering Education*, (1988),**78**, 4, 674-681.
10. M. H. McCaulley, The MBTI and individual pathways in engineering design, *Engineering Education*, **80** (1990), pp. 537–542.
11. R. M. Felder, K. D. Forrest, L. Baker-Ward, E. J. Dietz and P. H. Mohr, A longitudinal study of engineering student performance and retention: I. Success and failure in the introductory course, *J. Engineering Education*, **82**, 1, (1993), pp. 15–21.
12. H. Gardner, *Multiple Intelligences: The Theory in Practice*, New York: Basic Books (1993).

Terrance P. O'Brien, Associate Professor, Department of Curriculum and Instruction, College of Education and Psychology, North Carolina State University, received a Bachelor of Science in Secondary Education (1977) and a Master of Science in Education (1977) from Old Dominion University, Norfolk, Virginia. Received a Doctor of Philosophy in 1981 from Ohio State University, Columbus. Dr O'Brien has been a faculty member in Colleges of Education at The Ohio State University, Auburn University, and North Carolina State University. He has published extensively in educational and psychological journals on relationships between cognitive styles and academic achievement in a variety of educational environments.

Leonhard E. Bernold, Associate Professor, Department of Civil Engineering, North Carolina State University, is a native of Switzerland. He received a diploma in Civil Engineering from the Swiss Institute of Technology in 1978, an MS in Industrial Management from Georgia Tech in 1983, and a Ph.D. in Construction Engineering and Management from Georgia Tech in 1985. Dr Bernold spent five years as an Assistant Professor at the University of Maryland before starting his present position in 1991. As the founder and director of the Construction Automation and Robotics Laboratory, he is involved in spearheading several innovative projects. He teaches courses in Construction Engineering and Management and conducts NSF-sponsored research related to engineering education.
Duane Akroyd, Associate Professor, Department of Adult and Community College Education, College of Education and Psychology, North Carolina State University, received his Ph.D. in Occupational Education from Southern Illinois University and MS in Health Science Education from the State University of New York at Buffalo. He currently co-ordinates the graduate program in Health Occupations Education.