The Effect of Individual Learning Styles On Student GPA In Engineering Education At Morgan State University

S. Keith Hargrove, John A. Wheatland, Duowen Ding
Morgan State University

Cordelia M. Brown
Purdue University

Abstract

The Clarence M. Mitchell School of Engineering at Morgan State University (MSU) is one nine historically Black colleges and universities with undergraduate engineering programs accredited by the Accreditation Board for Engineering and Technology (ABET). Since 2001, the School of Engineering at MSU has been a participant in a multi-school project called *Implementing the BESTTEAMS (Building Engineering Student Team Effectiveness and Management System) Model of Team Development Across the Curriculum*. The project's primary purpose is to introduce collaboration and teamwork in engineering education to improve the educational process and prepare students to work in collaborative environments after graduation. As a part of the BESTTEAMS model, students in the freshman course, Introduction to Engineering, are given the *Kolb's Learning Style Inventory*, a survey designed to measure learning styles. This paper will examine the relationship between students' learning styles, major, gender and academic performance in engineering at MSU. The cumulative GPA at the end of the first year for first-time freshmen that completed Introduction to Engineering was recorded and analyzed to determine the relationship between learning style preference and cumulative GPA by major and gender. It is the long term intent of this exploratory study to determine if learning styles are a major consideration in designing courses to improve academic performance and achievement in engineering and if there is a significant difference between the relationship of learning styles and academic performance when gender is considered.

Key Words: Learning style, the *Kolb's Learning Style Inventory*, learning environment, statistical method, project team environment, and GPA.

INTRODUCTION

A learner's individual differences can be captured and categorized through learning styles or the Myers-Briggs Type Indicator (Aysersman & Von Minden, 1995; Lawrence, 1994). There are many learning style models. Some of the most widely employed models are: Kolb's model (Kolb, 1981; Kolb, 1984; Kolb, 2000; Kolb & Kolb, 2006; Stice, 1987), Dunn and Dunn model (Dunn, 2000), Herrmann Brain Dominance model (Lumsdaine & Lumsdaine, 1995), VARK model (Fleming, 1995), and the Felder-Silverman learning model (Felder & Silverman, 1988). Learning styles can be described as "an individual's preferred approach to organizing and presenting information"(Riding & Rayner, 1998). It can also be described as "the way in which learners perceive, process, store, and recall attempts of learning"(James & Gardner, 1995). The matching of learning styles with a learning environment influence learners' outcomes and learning process.

The largest increases in achievement are among students with active, sensing, and global learning preferences in a course offered in a hypermedia-assisted learning environment. However, there is no significant difference between students with different learning styles in this course (Malgorzata, 2002). An objective of education should thus be to help students build their skills in both their preferred and less preferred learning style (Felder, 1996).

Previous research has indicated that female and male engineering students often have different learning styles and abilities when they enter college (Fowler, Armarego, & Allen, 2001; Agogino & Hsi, 1995). With most engineering faculty being male, their learning styles and teaching styles tend to resemble those of male students more often than female students (Fowler, Armarego, & Allen, 2001). Although females often enter engineering school with better academic credentials, had parents with technical backgrounds who were better educated than male student parents, and scored better on admission and standardize tests, they start with greater anxiety and have less confidence about their abilities (Felder, Felder, Mauney, Hamrin, & Dietz, 1995). In one study, females in chemical engineering did not perform as well as males after the first year and over a four-year period. Females in good standing were more likely to transfer out of engineering than males in good standing (Felder, Felder, Mauney, Hamrin, & Dietz, 1995). In another study of science, engineering, and math (SEM) students, females with higher entering credentials, academically performed better than males after the first year, but were only retained within the SEM fields at the same rate males (Wheatland, 2002). Females had stronger predictors of success, but did not perform better than males. A difference in learning styles may help explain these results.

This paper attempts to explore the relationship of learning styles on students' GPA, by major and gender, in the School of Engineering at

MSU. The results of the study can help instructors and advisors to understand their students and design instruction that can be suited to students with different learning styles. Knowing their own learning styles is useful to students in becoming an effective team member and in making their learning styles match the learning environment to obtain the largest outcomes.

KOLB'S LEARNING STYLE

A major step towards increasing a student's learning power and learning experiences is understanding learning style types — both the strengths and weaknesses. In the Kolb's learning style model, the four basic learning modes are concrete experience (CE), abstract conceptualization (AC), reflective observation (RO), and active experience (AE) (Kolb, 1984). Because each individual's learning style is a combination of the four basic learning modes, Kolb's learning styles is further classified into the following four types: Accommodator, Diverger, Converger, and Assimilator (Kolb, 1984). Figure 1 presents a graphical representation of Kolb's Experiential Learning Cycle and Basic Learning Styles.

- Converger: "The dominant learning abilities are abstract conceptualization and active experimentation. Greatest strength lies in practical application of ideas. Tend to do best when there is a single correct answer or solution to a question or problem. Relatively unemotional, preferring to deal with things rather than people. Tend to have narrow interests and often choose to specialize in physical sciences. Many engineers have this learning style" (Kolb, 1984; Stice, 1987; Kolb, 1981).
- Diverger: "Best at concrete experience and reflective observation. Greatest strength lies in imaginative ability. Excel in ability to view concrete situations from many perspectives and to organize many relationships into a meaningful "gestalt." Perform better in situations that call for generation of ideas such as "brainstorming". Interested in people and tend to be imaginative and emotional. Have broad cultural interests and tend to specialize in the arts. Counselors, organization development consultants, and personnel managers often have this learning style" (Kolb, 1984; Stice, 1987; Kolb, 1981).
- Assimilator: "The dominant learning abilities are abstract conceptualization and reflective observation. Greatest strength lies in ability to create theoretical models. Excel in inductive reasoning, in assimilating disparate observations into an integrated explanation. Less interested in people and use of theories. More important that theory be logically sound and precise. More characteristic of the basic sciences and mathematics than of applied sciences. Learning style found most often in the research and planning departments" (Kolb, 1984; Stice, 1987; Kolb, 1981).
- Accommodator: "Best at concrete experience and active experimentation. Greatest strength lies in doing things, in carrying out plans and experiments and becoming involved in new experiences. Tend to be risk-takers more than persons with other three learning styles. Tend to excel in situations that call for adaptation to specific immediate circumstances. Tend to solve problems in an intuitive trial-and-error manner, relying heavily on other people for information rather than their own analytical ability. Are at ease with people but are sometimes seen as impatient and "pushy". Educational backgrounds often in technical or practical fields such as business. In organizations, people with this learning style are often found in "action-oriented" jobs, often in marketing or sales" (Kolb, 1984; Stice, 1987; Kolb, 1981).

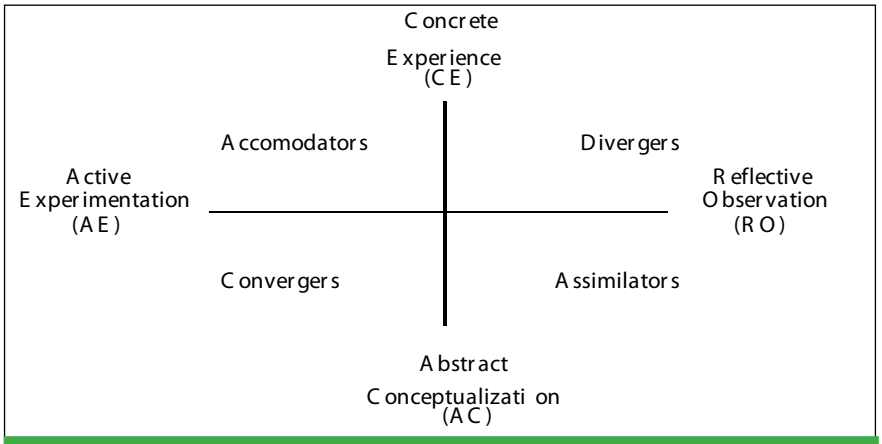

Figure 1: Kolb's Experiential Learning Cycle and Basic Learning Styles (Kolb, 1984; Kolb, Boyatzis, Mainemelis, 2000). Reproduced with permission from Alice Kolb, Experience Based Learning Systems, Inc.

Kolb learning styles have been studied in engineering courses. "Researchers have found that the percentages of engineering students categorized by learning style listed in rank order from most to least are convergers and assimilators (about equal percentages) first, accommodators second, and divergers last" (Elkins, Rafter, Eckart, Rutz, & Maltbie 2002; Harb, Durrant, Terry, 1993; Sharp, 2006; Sharp, Harb, Terry, 1997; Stice, 1987).

Students (n = 232)			GPA	
			Mean	Std. Deviation
Accommodator	33	14.22%	2.6735	0.9040
Assimilator	103	44.40%	2.6384	0.8200
Converger	55	23.71%	2.7869	0.7904
Diverger	41	17.67%	2.4048	0.6815

Table 1: Kolb's Learning Style Distributions and GPA in MSU's School of Engineering

METHODOLOGY

From the Fall 2001 through the Fall 2003 semesters, 232 students majoring in Civil, Electrical, and Industrial Engineering at MSU in the freshman class, Introduction to Engineering, took the *Kolb's Learning Style Inventory* survey. The *Kolb's Learning Style Inventory* was used to capture learner preferences. The following steps were used to complete scoring the *Kolb Learning Style Inventory*.

1. Students answered 12 questions on a survey sheet.
2. Using a scoring guide, students calculated totals for the RO (Reflective Observation), AE (Active Experimentation), AC (Abstract Conceptualization), and CE (Concrete Experience) modes of learning scales.
3. On a circle graph, students marked the AE value on the Active Experimentation axis, CE value on the Concrete Experience axis, RO value on the Reflective Observation axis and AC value on the Abstract Conceptualization axis and connected the four points to form a four-sided polygon (kite-shaped).
4. On a rectangular graph, students plotted the (X, Y) coordinate pair where the X value equals the AE score minus the RO score and Y value equals the AC minus the CE score. According to which of four quadrants the (X, Y) coordinate pair falls, it identifies one of the four Kolb learning styles (Converger, Assimilator, Diverger, and Accommodator).

In the School of Engineering at MSU, the courses are taught using a mixture of lectures and active learning experiences in class, combined with a combination of individual and team-based assignments. The mode of instruction and assignments expect to fully accommodate the different learning style preferences of diverse learners. At the end of each semester that the 232 students took the introductory freshman class, their first semester GPAs were recorded.

After the scores were received, statistical analysis was performed for the entire cohort as well as for each individual major. The statistical analysis examined the Kolb's learning style preferences and GPA. It investigated similarities and differences in the Kolb's learning style preferences of males and females. This study also briefly compared the Kolb's learning style distribution of MSU's engineering students to other engineering students.

RESULTS

The study was comprised of 232 freshman students who completed the *Kolb's Learning Style Inventory* during the first year of their college education. The students were 15.5% Civil Engineering majors, 74.5% Electrical Engineering majors, and 9.5% Industrial Engineering majors. Kolb learning style distributions of the School of Engineering are shown in Table 1 and Figure 2. There were 14.22% of the students of Accommodator preference, 44.40% of Assimilator preference, 23.71% of Converger preference, and 17.67 % of Diverger preference.

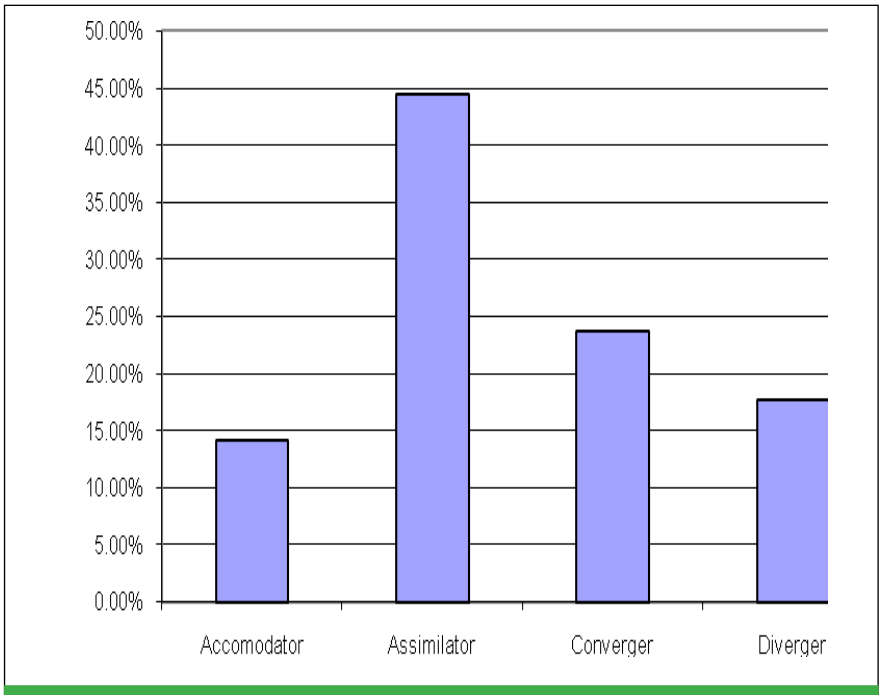

Figure 2: Kolb's Learning Style Distributions in MSU's School of Engineering, N = 232

Students (n = 37)			GPA	
			Mean	Std. Deviation
Accommodator	9	24.32%	2.43	1.05
Assimilator	12	32.43%	2.51	0.67
Converger	10	27.03%	2.63	0.71
Diverger	6	16.22%	2.74	0.37

Table 2: Kolb's Learning Style Distributions and GPA Data in Civil Engineering

Students (n = 173)			GPA	
			Mean	Std. Deviation
Accommodator	22	12.72%	2.71	0.85
Assimilator	79	45.67%	2.70	0.86
Converger	40	23.12%	2.80	0.83
Diverger	32	18.49%	2.36	0.69

Table 3: Kolb's Learning Style Distributions and GPA Data in Electrical Engineering

Students (n = 22)			GPA	
			Mean	Std. Deviation
Accommodator	2	9.09%	3.45	0.75
Assimilator	12	54.55%	2.38	0.70
Converger	5	22.73%	2.38	0.75
Diverger	3	13.64%	2.18	1.03

Table 4: Kolb's Learning Style Distributions and GPA Data in Industrial Engineering

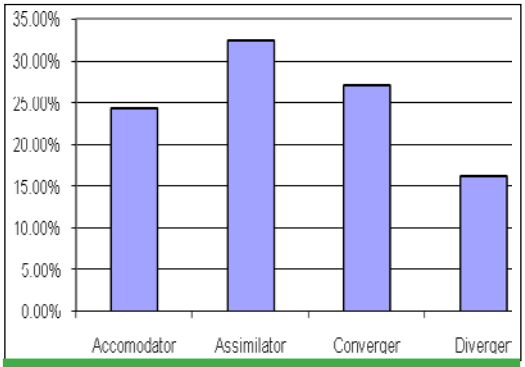

Figure 3: Kolb's Learning Style Distributions in MSU's Department of Civil Engineering, N = 37

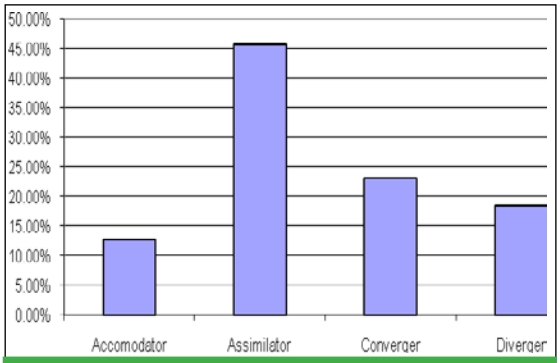

Figure 4: Kolb's Learning Style Distributions in MSU's Department of Electrical Engineering, N = 173

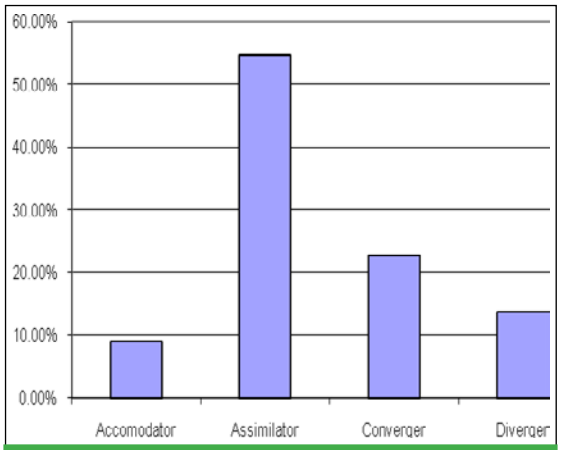

Figure 5: Kolb's Learning Style Distributions in MSU's Department of Industrial Engineering, N = 22

The Kolb's learning style distributions for students majoring in Civil Engineering, Electrical Engineering, and Industrial Engineering are shown in Tables 2 - 4 and Figures 3 - 5.

Figure 6 displays box plots of the GPAs of the students in the School of Engineering according to their different learning style preferences.

There were more students with an Assimilator preference than any other learning style. This was true within all majors, but was most pronounced in Electrical and Industrial Engineering. In Civil Engineering, learning style preferences were more evenly distributed, but Accommodators accounted for a higher percentage of students in this major than in the other two majors.

Kolb's Learning Style Inventory has been administered to undergraduate engineering students at other schools (Hunkeler & Sharp, 1997; Harb, Terry, & Sharp, 1994). Table 5 displays a comparison of Kolb's learning style distributions in undergraduate engineering programs. The other undergraduate engineering students were from University of Texas, Oregon State University, Brigham Young University, and Vanderbilt University. Population I groups University of Texas, Oregon State University, and Brigham Young University together. Population II is Vanderbilt University. Population III is Morgan State University. Population I and III reported Assimilator to be the most prevalent learning style followed by Converger. Population II's learning style distribution was the opposite. Converger is slightly more prevalent than Assimilator. Population I and II reported Accommodator as the third most prevalent learning style. Population III reported Diverger as its third. Population I and II report Diverger as its least prevalent learning style. Population III reported Accommodator as the least prevalent. In Population II, there is only a 2% difference between Assimilator and Converger; whereas, in Population I, the difference is 10%, and in Population III, the difference is 20.69%. There are slight variations in learning style distributions of Population I and II compared to the distributions noticed in the Morgan State University students.

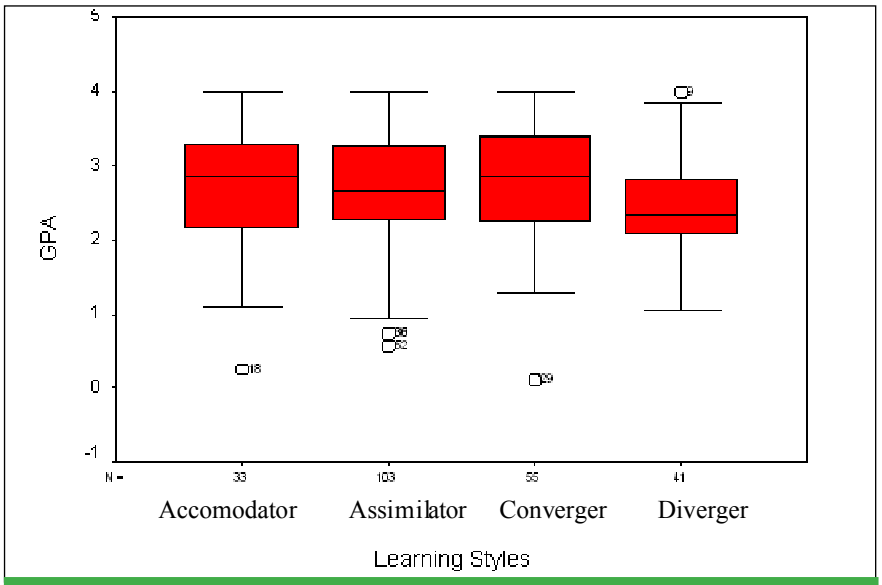

Figure 6: Box Plots of MSU's School of Engineering Students' GPA Versus Students' Kolb Learning Style Preference

The GPA scores for the 232 Morgan State University students in the study were analyzed. Several significant differences in freshman year academic performance were observed. Figure

	Population I*	Population II**	Population III***
Accommodator	20%	13%	14.22%
Assimilator	40%	38%	44.40%
Converger	30%	40%	23.71%
Diverger	10%	9%	17.67%

* Population I consists of undergraduate engineering students from the University of Texas, Oregon State University, and Brigham Young University.
** Population II consists of undergraduate engineering students from Vanderbilt University.
*** Population III consists of undergraduate engineering students from Morgan State University.

Table 5: Comparison of Kolb's Learning Style Distributions (Hunkeler & Sharp, 1997; Harb, Terry, & Sharp, 1994)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F_0	p-Value
Learning Styles	3.49	3	1.16	1.81	0.146116
Error	147.05	228	0.64		
Total	150.54				

Table 6: Analysis of Variance for the Students' GPA Data

6 presents box plot for GPA of different learning style preference of students in the School of Engineering. The analysis of variance (ANOVA) test was used to test the students' GPA differences between learning styles. Due to the unbalanced data, the analysis equation can be expressed as follows:

$$SS_T = \sum_{i=1}^{a}\sum_{j=1}^{n_i} y_{ij}^2 - \frac{y_{..}^2}{N} \quad (1)$$

$$SS_{Treatments} = \sum_{i=1}^{a} \frac{y_{i.}^2}{n_i} - \frac{y_{..}^2}{N} \quad (2)$$

$$SS_E = SS_T - SS_{Treatments} \quad (3)$$

$$F_0 = \frac{MS_{Treatments}}{MS_E} \quad (4)$$

where SS_T is the total sum of squares; $SS_{Treatments}$ is the total sum of squares due to treatments; SS_E is called the sum of squares due to error; F_0 is the ratio of mean square of treatment $MS_{Treatments}$ and mean square of error MS_E; a is the total number of treatments or levels; n_i is replicates of treatment i, y_{ij} represents the jth observation taken under factor level or treatment i; $y_{..}$ and $y_{i.}$ are expressed symbolically,

$$y_{..} = \sum_{i=1}^{a}\sum_{j=1}^{n_i} y_{ij} \quad (5)$$

$$y_{i.} = \sum_{j=1}^{n_i} y_{ij} \quad (6)$$

The results of variance analysis test are summarized in Table 6.

The analysis by variance test shows that with a level of significance of $\alpha = 0.15$, the GPA of students with different learning style preferences is significantly different.

The analysis by variance test shows that with a level of significance of $\alpha = 0.15$, the GPA of students with different learning style preference is significantly different. Further, the comparison among different learning style types was analyzed through the two-sample t-test based on the data in Table 1. The results are summarized in Table 7. The asterisk indicates a significant difference in GPA at the significance level of $\alpha = 0.15$.

For the overall freshman year GPA, students with the Accommodator preference outperformed students with the Diverger preference (2.6735 to 2.4048, p = 0.07); Assimilators outperformed Divergers (2.6384 to 2.4048, p = 0.04); and Convergers outperformed Divergers (2.7869 to 2.4048, p = 0.001). Convergers outperformed Assimilators in overall GPA, but the difference is not statistically significant (2.7869 to 2.6384, p = 0.18). Convergers outperformed Accommodators and Accommodators outperformed Assimilators, but these differences are not statistically significant.

	ACC. (2.673)	ASS. (2.638)	CON. (2.787)	DIV. (2.405)	Rank
ACC. (2.673)	-	⇧	⇩	⇧*	2
ASS. (2.638)	⇩	-	⇩	⇧*	3
CON. (2.787)	⇧	⇧	-	⇧*	1
DIV. (2.405)	⇩*	⇩*	⇩*	-	4

Table 7: Comparison of MSU's School of Engineering Students' GPAs with Different Learning Styles

The effect of learning styles of Civil Engineering, Electrical Engineering, and Industrial Engineering students on the student's GPA has been analyzed. In Civil Engineering, Divergers outperformed Accommodators, Convergers, and Assimilators but the difference is not statistically significant. In Electrical Engineering, Convergers outperformed Divergers (2.80 to 2.36, p = 0.003), Accommodators outperformed Divergers (2.71 to 2.36, p = 0.03). Assimilators outperformed Divergers (2.70 to 2.36, p = 0.016). Convergers outperformed Accommodators and Assimilators, but the differences are not statistically significant. In Industrial Engineering, Accommodators outperformed Divergers (3.45 to 2.18, p = 0.22), but the difference is not statistically significant. Accommodators outperformed Assimilators (3.45 to 2.38, p = 0.03) and Convergers (3.45 to 2.38, p = 0.07), but the difference is not statistically significant.

Similar techniques were used to analyze the relationship between gender, GPA, and Kolb's learning style. Tables 8 and 9 summarize that data.

The data shows that the distribution of learning styles between males and females in the School of Engineering is very similar. The data also shows that female students, with a GPA of 2.7305, performed better academically than male students, with a GPA of 2.5892. An ANOVA test of female students indicated that

Students (n = 79)			GPA	
			Mean	Std. Deviation
Accommodator	13	16.50%	2.7741	1.0201
Assimilator	34	43.00%	2.7724	0.7207
Converger	18	22.80%	2.7653	0.9316
Diverger	14	17.70%	2.5436	0.7381

Table 8: Female – Kolb's Learning Style Distributions and GPA in MSU's School of Engineering

Students (n = 153)			GPA	
			Mean	Std. Deviation
Accommodator	20	13.10%	2.6081	0.8412
Assimilator	69	45.10%	2.5724	0.8620
Converger	37	24.20%	2.7974	0.7258
Diverger	27	17.60%	2.3328	0.6530

Table 9: Male – Kolb's Learning Styles Distributions and GPA in MSU's School of Engineering

there were no significant differences between female GPAs across learning styles. A comparison of female student GPAs with different learning styles is summarized in Table 10. Female students with an Accommodator learning style on average had the highest GPA, followed by Assimilator, Converger, and Diverger, respectively.

An ANOVA for male students in Table 11 indicated significant differences between male GPAs across learning styles.

A comparison of male student GPAs with different learning styles is summarized in Table 12.

Male students with a Converger learning style on average had the highest GPA, followed by Accommodator, Assimilator, and Diverger, respectively. The difference in GPA between male Convergers and Divergers was statistically significant. The comparisons between GPAs for certain learning styles for males and females were found to be different, as shown by the shaded entries in Table 10 and Table 12. For female students, the GPA for students with Accommodator and Assimilator preferences is higher than students with Converger preferences. Conversely, for male students, the GPA for Accommodator and Assimilator preferences is lower than students with Converger preferences.

	ACC. (2.774)	ASS. (2.772)	CON. (2.765)	DIV. (2.544)	Rank
ACC. (2.774)	-	⇧	⇧	⇧	1
ASS. (2.772)	⇩	-	⇧	⇧	2
CON. (2.765)	⇩	⇩	-	⇧	3
DIV. (2.544)	⇩	⇩	⇩	-	4

(*) Significantly different at α= 0.15 ☐ Different for males and females

Table 10: Comparison of Female Student GPAs with Different Learning Styles

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F_0	p-Value
Learning Styles	3.409	3	1.135	1.799	.150
Error	94.026	149	.631		
Total	97.431				

Table 11: Analysis of Variance of GPA by Male Learning Styles

CONCLUSIONS

The distribution of Kolb's learning styles in Morgan State University's School of Engineering varied between students majoring in Civil, Electrical and Industrial Engineering. In each of the three majors, more students had the Assimilator learning style than any other. This learning style was held by nearly half of the Electrical Engineering student and slightly more than half of the students in Industrial Engineering. In Civil Engineering, the number of students with the Assimilator learning style was closely followed by those with the Converger and Accommodator learning styles.

Overall, GPA varied with learning styles, Convergers had the highest average GPA and Divergers had the lowest. The average GPAs for students in each major were close to the overall average GPA of 2.64 for all students. In Civil Engineering, GPAs in each learning style were consistently close to one another, but rising slightly from Accommodator to Assimilator to Converger to Diverger, respectively. In Electrical Engineering, the average GPA across learning styles was consistent except for Divergers, where it was considerably lower. In Industrial Engineering, the average GPA across learning styles was consistent except for Accommodators, where it was considerably higher by over one letter grade.

When it came to gender, learning styles were distributed very similarly between male and female students. For female students, the average GPA across learning styles was very consistent except for Divergers, where it was slightly lower. Among female students, those with the Accommodator learning style had the highest average GPA when compared to those with other learning styles. For male students, the average GPAs across learning styles exhibited more variation when compared to those of female students. Among male students, those with the Converger learning style had the highest average GPA when compared to those with other learning styles.

There are limitations to the study. The numbers are small when categorized by major and gender. These limitations also provide opportunities to expand the data collection longitudinally. Future research will be conducted to determine the learning (teaching) styles of the faculty in the School of Engineering and to compare them to the learning styles of our students. In addition, we will examine the relationships between learning styles, student retention, and graduation rates in Morgan State University's School of Engineering.

	ACC. (2.608)	ASS. (2.572)	CON. (2.797)	DIV. (2.333)	Rank
ACC. (2.608)	-	⇧	⇩	⇧	2
ASS. (2.572)	⇩	-	⇩	⇧	3
CON. (2.797)	⇧	⇧	-	⇧*	1
DIV. (2.333)	⇩	⇩	⇩*	-	4

(*) Significantly different at α= 0.15 ☐ Different for males and females

Table 12: Comparison of Male Students GPAs with Different Learning Styles

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Dr. S. Keith Hargrove, Sr., currently serves as Chairperson of the Department of Industrial, Manufacturing & Information Engineering Department in the Clarence Mitchell, Jr. School of Engineering at Morgan State University, Baltimore, Maryland. He most recently completed the Boeing Welliver Faculty Fellowship Program, completing internships in commercial and military aircraft production. He received his BS in Mechanical Engineering from Tennessee State University in Nashville, TN., M.S. from The Missouri University of Science & Technology in Rolla, MO., and Ph.D. in Industrial & Manufacturing Engineering from The University of Iowa, Iowa City, IA. He has worked as a research engineer for several national laboratories, General Electric, and is a Senior Member of the Institute of Industrial Engineers, Society of Manufacturing Engineers, and a member of the Maryland Society of Professional Engineers.

Dr. John A. Wheatland, is currently the Director of Freshman Programs in the Clarence M. Mitchell, Jr. School of Engineering at Morgan State University. There, he teaches the engineering orientation course, Introduction to Engineering, is the Alliance for Minority Program (AMP) Coordinator, and works extensively in retaining and graduating students in science, technology, engineering, and mathematics (STEM) areas. Dr. Wheatland had a successful eighteen-year career with IBM as a systems engineer, manager, and application specialist in manufacturing, state and local government finance and administrative systems, and office systems. He received his Bachelor of Electrical Engineering degree from the City College of New York in 1972 and his Master of Science in Electrical Engineering degree from the University of Bridgeport in 1974. In 1993, he was certified in Production and Inventory Management (CPIM) by the American Production and Inventory Control Society. In May 2000, he received his Doctorate of Education in Urban Education Leadership from Morgan State University.

Dr. Duowen Ding, is a post-doctoral research associate in the Department of Industrial, Manufacturing & Information Engineering in the Clarence Mitchell, Jr. School of Engineering at Morgan State University. He recently completed his Doctor of Engineering degree from Morgan State University in assisting with this study on student retention and learning styles in engineering education.

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Dr. Cordelia M. Brown is an Assistant Professor in the School of Electrical and Computer Engineering, and the School of Engineering Education at Purdue University. She received her Ph.D. in Electrical Engineering from Vanderbilt University in 2005. Dr. Brown earned a M.S. degree in Electrical Engineering from Vanderbilt University in 2001. She earned her BS degree in Electrical Engineering from Tuskegee University. Her research area is in the development of learning models, learning styles, assessment of instructional methods, laboratory design, cooperative learning, and retention and recruiting issues in Science, Technology, Engineering, and Mathematics education.