Evaluation Report: NACME AMLI Boot Camp supported by Google.org
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Introduction and Executive Summary

As technological innovation and advancement continues to impact all industries and sectors of the economy, influencing every aspect of our lives including how we work, learn, and communicate, computational literacy is critical for all students. Despite the increased significance of computer science education, computational thinking, and computing literacy across all fields and occupations, access to computer science education is unequally distributed by race, gender, socioeconomic status, and geography. Google AMLI Bootcamp was designed in collaboration with NACME and Google education to address this issue. Sponsored by the National Action Council for Minorities in Engineering (NACME) and Google Education, an eight-week program exposed under-represented minority (URM) undergraduate students to advanced concepts in artificial intelligence and machine learning (ML) using Google Education’s open-sourced curriculum. Participating students receive full room and board for the duration of the program, a travel stipend to cover arrival and departure costs and upper-level computer science elective course credit for completing the bootcamp. Instructors dedicated classroom time to hands-on learning featuring faculty-supported, collaborative project work. Students were also granted access to a professional development webinar series where they were introduced to inspiring technology professionals sharing critical aspects for launching and sustaining a successful career.
For two consecutive summers, 2021 and 2022, NACME coordinated the Google AMLI Bootcamp. Three innovative models for course delivery were utilized:

1. University of Kentucky – in person instructions both summers
2. University of Arkansas – partial in person instruction both summers
3. Morgan State University – completely online in 2021 and partial in person instruction for 2022

To support the long-term development of the project NACME commissioned an evaluation study. The evaluation plan was designed to provide feedback on progress toward meeting the learning objectives outlined in the curriculum as well as formative aspects to guide evidence-based based decisions about changes in activities through daily feedback from students on assessment of learning of the content. Students also provided weekly feedback on the program activities and the professional development series. Input was also collected from faculty/instructors and teaching assistants on their experience with delivering the content and helping students acquire knowledge to support their overall learning. This comprehensive report includes a description of the instruments/metrics for the project and disaggregated data by performance site on a weekly basis. Participant data is also disaggregated data by race, ethnicity, gender, academic
A pre-survey was administered to students enrolled in the Applied Machine Learning course during the first week of the course. A total of 59 students responded across the three institutions. The typical student identified as male (62.7%), African American (55.9%), non-Hispanic (54.2%) and without a disclosed disability (93.2%). Nearly 60% of the students were of junior or senior status and 55.9% reported majoring in Engineering and approximately 60% expected to earn at least a Masters’ degree. Sample characteristics were not requested on the post survey.

A longitudinal design (pre-post) was also used to examine changes (improvements) for course participants (students, faculty and teaching assistants) over the eight-week course. Throughout the eight-week courses, students were provided the opportunity to provide daily and weekly feedback and a sample of students participated in a focus group. A total of 61 students were participated in the course from three different sites (Arkansas, n=21, Kentucky, n=17, Morgan State, n=23). Faculty offered instruction from Arkansas and Kentucky on alternative days with teaching assistants provided at all three sites.

Students expected this Applied Machine Learning course to be valuable with 85% indicating that they expected the course to be helpful in getting an internship and 81% believing it would be helpful in getting a job. In addition, 69% indicated that they wanted to learn more about machine learning and they would learn something useful for their other classes. While faculty and TAs also believed that this course would be helpful in getting internships and jobs, they most strongly believed students enrolled because they liked the applications of machine learning.

Daily and weekly feedback provided over the first 7 weeks of the course was positive. Daily feedback was generally most positive in relation to the instructor’s command of the content and the helpfulness of the teaching assistants (TAs) with responses consistently averaging above 4.0 (using a 5-point scale). Weekly feedback was also supportive with overall average responses above 4.0 for 5 of the 7 weeks. Students responded most favorably in weeks 1 and 7 and least favorably toward the midway points in weeks 4 and 5 when students expressed some difficulty keeping up with the pace and understanding what was addressed in class. A focus group with students after week 3 also revealed participating virtually created technical and learning challenges and these students preferred to have an instructor in the room with them and that was often reflected in the numerical responses to the daily and weekly feedback.
Post course responses were very positive with all averaging above 3.75 and 11 of the 15 above 4.0. Students reported great improvement in their confidence to complete their degree (M=4.2) and earn an advanced degree or get a job after graduation (M=4.3). They also reported great improvement in their communication skills (M=4.23), problem-solving ability (M=4.26) and ability to work effectively with others (M=4.28). Overall, students planned to keep in touch with other students from the course (M=4.51) and valued the residential component (M=4.43). They also established strong relationships with faculty and planned to keep in touch (M=4.23) and believed they were better prepared for the coming year (M=4.28). Finally, getting a stipend was important to them (M=4.41).

Faculty reported high levels and improved levels of confidence in their ability to teach Engineering concepts, use instructional and assessment strategies, motivate students to learn and engage students in the learning process. TAs were especially confident that they helped students with their teamwork, technology, communication and critical thinking skills and reported improved confidence in their ability to create a positive learning environment, use instructional strategies and perform their essential TA duties. In addition, TAs became more confident in their ability to help students give and receive feedback, prepare presentations and deliver strong oral presentations and were especially confident that they helped students with their teamwork, technology, communication and critical thinking skills.

Students indicated moderate to high levels of confidence in their knowledge and abilities related to the Applied Machine Learning Course student learning outcomes and in the specific topics addressed in the course with all post-course responses exceeding those prior to the course. At the end of the course, students also reported greater engineering self-efficacy (general and skill-related), confidence in their 21st century skills (e.g. working with peers and persons with different backgrounds), intention to persist and readiness for a career. A matched sample of 59 students was examined to determine the extent to which students changed (improved) from the beginning of the course to the end and resulted in improvements for 14 of the 16 examined scales. After controlling for Type 1 error, statistical significance was found in relation to student confidence in their knowledge and skills required for the machine learning topics addressed in the course and the expected student learning outcomes at each site. Follow-up analysis revealed statistically significant improvement for all six SLOs and 34 of the 39 topics. Students participating at Kentucky also reported statistically significant increases in their confidence and ability related to the ABET SLOs, engineering efficacy and peer learning.
A longitudinal design (pre-post) was also used to examine changes (improvements) for students while faculty and TAs were only requested to provide feedback at the end of the course. Throughout the eight-week courses, students were provided the opportunity to provide weekly feedback and a sample of students participated in a focus group. In 2022, a total of 62 students were participated in the course from three different sites (Arkansas, n=21, Kentucky, n=17, Morgan State, n=24). The typical student identified as male (74.6%), African American (74.6%), non-Hispanic (73%) and without a disclosed disability (90.5%). Overall, nearly 60% of the students were of junior or senior status and 55.6% reported majoring in Engineering and over 40% expected to earn at least a Masters’ degree. In 2021, faculty offered instruction from Arkansas and Kentucky on alternative days with teaching assistants provided at all three sites.

Students expected this Applied Machine Learning course to be valuable for a variety of reasons. In the overall sample, over 50% indicated that they thought they would learn something useful for their classes (60%), were curious to know more about machine learning (60%), just wanted to learn something new (60%), thought the course would be helpful in getting an internship (61%) and getting a job (66%).

Weekly feedback was summarized from the first 6 weeks in relation to the quality of instruction and professional development (PD) sessions. Students responded each week and indicated was of high quality with overall average responses of 4 or above in weeks 1 to 5 and just slightly lover (3.93) in week 6. While students believed that instructors demonstrated command of content knowledge and that they were learning things useful for their other classes and their careers, they did have a more difficult tome keep up with the pace and indicated that they did not have as good an understanding of the materials as the weeks progressed. Students found the PD sessions to be of great interest, they helped them think of additional PD opportunities, helped prepare for potential internships and motivated them to improve their preparation for a career in Engineering.

Post course feedback was very positive with over 90% of students indicating that they gained valuable knowledge and learned useful applications related to machine learning and valued the networking with other students. Students also strongly agreed that they established strong relationships with faculty and will keep in touch (M=4.31), planned to keep in touch with students they met (M=4.34) and are better prepared for the
coming year after completing this course (M=4.34). Furthermore, students’ retrospective pre-post feedback was very positive with an overall average of 4.08 (using a 5-point scale). Students expressed the most improvement in their confidence that they will get a job earn and advanced degree upon graduation (M=4.40) and their awareness of potential careers in machine learning (M=4.31).

Post course feedback also provided support for culturally responsive teaching with an overall scale average of 3.93 (using a 5-point scale) and all 27 items averaging above 3.5. Students most strongly agreed that their instructors explained new concepts using examples taken from students’ everyday lives (M=4.15), built a sense of trust in students (M=4.16) and developed personal relationships with students (M=4.23). Students strongly believed that culturally responsive teaching would be expected to result in positive outcomes with an overall scale average response of 4.45 (using a 5-point scale). More specifically, students strongly agreed that when students see themselves in the pictures and examples used in class, they develop a positive self-identity (M=4.52), using a variety of instructional approaches helps students be successful (M=4.54), students are more motivated and engaged when a personal relationship is established between the instructor and student (M=4.55) and students will be successful when instruction is adapted to meet their needs (M=4.57).

Finally, a matched sample of students was examined to determine the extent to which students changed (improved) from the pre course to post course survey administrations. Students reported improvement each of the 11 scales examined with 9 of these 11 comparisons reaching the minimum criteria for statistical significance (< .05). More specifically, students significantly improved their confidence in meeting each of the 6 ML course student learning outcomes and their confidence related to 38 of the 39 course topics/units. In addition, students also reported significant higher engineering efficacy, confidence in meeting the ABET SLOs and persistence at the end of the course.

As a result of participating in the Google AMLI bootcamp students at all sites showed significant gains in their knowledge of machine learning concepts. The analysis of results, in Tables 1-3, from the 2022 Google AMLI bootcamp show students reported significant gains in their knowledge of the machine learning student learning objectives (SLOs) at each site. While the detailed weekly analysis of feedback from students by site showed some variation in level of confidence in grasping the concepts, over time each site showed significant increases in students knowledge of machine learning concepts. Therefore each model can serve as an effective model for increasing machine learning content knowledge for students from historically underrepresented groups.
Conclusion

As a result of participating in the Google AMLI bootcamp students at all sites showed significant gains in their knowledge of machine learning concepts. The analysis of results, in Tables 1-3, from the 2022 Google AMLI bootcamp show students reported significant gains in their knowledge of the machine learning student learning objectives (SLOs) at each site. While the detailed weekly analysis of feedback from students by site showed some variation in level of confidence in grasping the concepts, over time each site showed significant increases in students knowledge of machine learning concepts. Therefore each model can serve as an effective model for increasing machine learning content knowledge for students from historically underrepresented groups.
Changes over time by Site the 2022 Google AMLI

Changes over the duration of the course were also examined for each site. These findings are summarized in the following tables.

- Over the duration of the course, students from the University of Arkansas reported improvement for 10 of the 11 scales summarized below with statistically significant improvement related to the course SLOs, ABET SLOs and confidence in the course content topic areas.

<table>
<thead>
<tr>
<th>University of Arkansas</th>
<th>Pre Couse</th>
<th>Post Course</th>
<th>t (p)</th>
<th>Effect Size (Cohen’s d)a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
<td>N</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>ML Course SLOs</td>
<td>20</td>
<td>2.41 (1.12)</td>
<td>4.16 (.76)</td>
<td>7.29***</td>
</tr>
<tr>
<td>ABET SLOs</td>
<td>20</td>
<td>3.86 (.87)</td>
<td>4.32 (.68)</td>
<td>2.36*</td>
</tr>
<tr>
<td>MK Course Unit Confidence</td>
<td>20</td>
<td>2.33 (.85)</td>
<td>3.87 (.66)</td>
<td>11.12***</td>
</tr>
<tr>
<td>Engineering Efficacy - Total</td>
<td>20</td>
<td>4.12 (.56)</td>
<td>4.33 (.66)</td>
<td>1.53</td>
</tr>
<tr>
<td>General</td>
<td>20</td>
<td>4.30 (.55)</td>
<td>4.53 (.67)</td>
<td>1.28</td>
</tr>
<tr>
<td>Skills</td>
<td>20</td>
<td>4.21 (.63)</td>
<td>4.47 (.59)</td>
<td>1.62</td>
</tr>
<tr>
<td>Design</td>
<td>20</td>
<td>4.03 (.67)</td>
<td>4.22 (.78)</td>
<td>1.16</td>
</tr>
<tr>
<td>Tinkering</td>
<td>20</td>
<td>3.98 (.71)</td>
<td>4.15 (.77)</td>
<td>1.17</td>
</tr>
<tr>
<td>Persistence</td>
<td>20</td>
<td>4.01 (.64)</td>
<td>4.31 (.73)</td>
<td>1.59</td>
</tr>
<tr>
<td>Career Development Units</td>
<td>19</td>
<td>4.01 (.66)</td>
<td>3.98 (.88)</td>
<td>-.196</td>
</tr>
<tr>
<td>Career Readiness</td>
<td>20</td>
<td>4.11 (.71)</td>
<td>4.18 (.69)</td>
<td>.384</td>
</tr>
</tbody>
</table>

* p<.05, ** p<.01, *** p<.001  
a: .2 = small, .5 = medium, .8 = large

Table 1 University of Arkansas Comparison of Pre and Post Results for 2022 Google Bootcamp
Changes over time by Site
the 2022 Google AMLI

Over the duration of the course, students from the University of Kentucky reported improvement for each of the 11 scales summarized below with statistically significant improvement related to the course SLOs, ABET SLOs, confidence in the course content topic areas, engineering efficacy and career readiness.

Table 2 University of Kentucky Comparison of Pre and Post Results for 2022 Google AMLI Bootcamp

<table>
<thead>
<tr>
<th>Scale</th>
<th>Pre Course</th>
<th>Post Course</th>
<th>t (p)</th>
<th>Effect Size (Cohen's d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML Course SLOs</td>
<td>17</td>
<td>2.31 (.89)</td>
<td>4.25 (.63)</td>
<td>7.51***</td>
</tr>
<tr>
<td>ABET SLOs</td>
<td>17</td>
<td>3.56 (.89)</td>
<td>4.34 (.59)</td>
<td>3.69**</td>
</tr>
<tr>
<td>MK Course Unit Confidence</td>
<td>17</td>
<td>2.24 (.73)</td>
<td>3.99 (.62)</td>
<td>8.89***</td>
</tr>
<tr>
<td>Engineering Efficacy - Total</td>
<td>17</td>
<td>3.85 (.52)</td>
<td>4.46 (.62)</td>
<td>3.86**</td>
</tr>
<tr>
<td>General</td>
<td>17</td>
<td>4.23 (.58)</td>
<td>4.61 (.55)</td>
<td>2.74*</td>
</tr>
<tr>
<td>Skills</td>
<td>17</td>
<td>4.10 (.60)</td>
<td>4.64 (.48)</td>
<td>3.99**</td>
</tr>
<tr>
<td>Design</td>
<td>17</td>
<td>3.85 (.77)</td>
<td>4.48 (.77)</td>
<td>3.79**</td>
</tr>
<tr>
<td>Tinkering</td>
<td>17</td>
<td>3.42 (.99)</td>
<td>4.22 (1.11)</td>
<td>3.68**</td>
</tr>
<tr>
<td>Persistence</td>
<td>17</td>
<td>4.00 (.56)</td>
<td>4.28 (.60)</td>
<td>1.78</td>
</tr>
<tr>
<td>Career Development Units</td>
<td>16</td>
<td>3.67 (.95)</td>
<td>4.04 (.86)</td>
<td>1.93</td>
</tr>
<tr>
<td>Career Readiness</td>
<td>17</td>
<td>3.84 (.79)</td>
<td>4.31 (.67)</td>
<td>3.13**</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01, ***p<.001
a=.2=small, .5=medium, .8=large
## Changes over time by Site the 2022 Google AMLI

Over the duration of the course, students from the Morgan State University reported improvement for 8 of the 11 scales summarized below with statistically significant improvement related to the course SLOs, confidence in the course content topic areas, and general and design engineering efficacy.

### Table 3 Morgan State University Comparison of Pre and Post Results for 2022 Google AMLI Bootcamp

<table>
<thead>
<tr>
<th>Scale</th>
<th>N</th>
<th>Pre Course</th>
<th>Post Course</th>
<th>t (p)</th>
<th>Effect Size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML Course SLOs</td>
<td>22</td>
<td>1.96 (.76)</td>
<td>3.79 (.57)</td>
<td>10.18***</td>
<td>2.17</td>
</tr>
<tr>
<td>ABET SLOs</td>
<td>22</td>
<td>3.61 (.76)</td>
<td>3.94 (.57)</td>
<td>1.92</td>
<td>.409</td>
</tr>
<tr>
<td>MK Course Unit Confidence</td>
<td>22</td>
<td>1.97 (.59)</td>
<td>3.23 (.75)</td>
<td>6.58***</td>
<td>1.40</td>
</tr>
<tr>
<td>Engineering Efficacy - Total General</td>
<td>22</td>
<td>3.99 (.72)</td>
<td>4.19 (.49)</td>
<td>2.07</td>
<td>.441</td>
</tr>
<tr>
<td>Engineering Efficacy - Total Skills</td>
<td>22</td>
<td>4.12 (.68)</td>
<td>4.35 (.58)</td>
<td>2.17*</td>
<td>.462</td>
</tr>
<tr>
<td>Engineering Efficacy - Total Design</td>
<td>22</td>
<td>4.10 (.73)</td>
<td>4.21 (.59)</td>
<td>1.03</td>
<td>.220</td>
</tr>
<tr>
<td>Engineering Efficacy - Total Tinkering</td>
<td>22</td>
<td>3.77 (.89)</td>
<td>4.14 (.58)</td>
<td>2.49*</td>
<td>.533</td>
</tr>
<tr>
<td>Persistence</td>
<td>22</td>
<td>4.04 (.53)</td>
<td>4.01 (.62)</td>
<td>-.169</td>
<td>-.036</td>
</tr>
<tr>
<td>Career Development Units</td>
<td>22</td>
<td>4.01 (.67)</td>
<td>3.97 (.73)</td>
<td>-.352</td>
<td>-.075</td>
</tr>
<tr>
<td>Career Readiness</td>
<td>22</td>
<td>4.24 (.55)</td>
<td>4.19 (.59)</td>
<td>-.451</td>
<td>-.098</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01, ***p<.001  
a-.2=small, .5=medium, .8=large
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Participants

Students - A pre-survey was administered to students enrolled in the Applied Machine Learning course during the first week of the course. A total of 59 students responded across the three institutions. The typical student identified as male (62.7%), African American (55.9%), non-Hispanic (54.2%) and without a disclosed disability (93.2%). Nearly 60% of the students were of junior or senior status and 55.9% reported majoring in Engineering and approximately 60% expected to earn at least a Masters’ degree. Sample characteristics were not requested on the post survey.
A total of 12 responses (Faculty = 4, TAs = 8) were recorded for the pre-instruction survey. The typical instructor (faculty and TA) identified as male, Asian, non-Hispanic and not disclosing a disability. There are a total of nine (9) responses on the post-course survey. The typical post-respondent identified as male, non-Hispanic, African American and not disclosing a disability. In addition, participants reported the number of days they were involved in the course.

<table>
<thead>
<tr>
<th>Sample Characteristics</th>
<th>Pre Course Survey</th>
<th>Post-Course Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Sample (N=12)</td>
<td>Faculty (n=4)</td>
<td>TAs (n=8)</td>
</tr>
<tr>
<td>Gender (Pronoun)</td>
<td>He (9(75%))</td>
<td>6(75%)</td>
</tr>
<tr>
<td></td>
<td>She (3(25%))</td>
<td>2(25%)</td>
</tr>
<tr>
<td></td>
<td>They (1(25%))</td>
<td>1(11.1%)</td>
</tr>
<tr>
<td></td>
<td>Prefer not to answer (1(11.1%))</td>
<td>1(11.1%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>No (12 (100%))</td>
<td>8(88.9%)</td>
</tr>
<tr>
<td></td>
<td>Yes (0)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Prefer not to answer (0)</td>
<td>1(11.1%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>Am. Indian/Alaskan Native (0)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Asian or Pacific Islander (7 (58.3%))</td>
<td>2(25%)</td>
</tr>
<tr>
<td></td>
<td>Black or African American (4 (33.3%))</td>
<td>1 (25%)</td>
</tr>
<tr>
<td></td>
<td>Nat Hawaiian or Pac Islander (1 (8.3%))</td>
<td>1 (25%)</td>
</tr>
<tr>
<td></td>
<td>White (0)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Other (0)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Prefer not to answer (0)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td>No (12 (100%))</td>
<td>7(55.6%)</td>
</tr>
<tr>
<td></td>
<td>Yes (4 (100%))</td>
<td>5 (55.6%)</td>
</tr>
<tr>
<td></td>
<td>Prefer not to answer (0)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation -Number of Classes</td>
<td>M=5.5, SD=2.1, Range=3-8</td>
<td>M=31, SD=8.9, Range=20-40</td>
</tr>
</tbody>
</table>
Why did Students Enroll in the Course?

Students expect this Applied Machine Learning course to be valuable with 85% indicating that they expected the course to be helpful in getting an internship and 81% believing it would be helpful in getting a job. In addition, 69% indicated that they wanted to learn more about machine learning and they would learn something useful for their other classes. While faculty and TAs also believed that this course would be helpful in getting internships and jobs, they most strongly believed students enrolled because they liked the applications of machine learning.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Overall Student Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
<th>Faculty (n=4)</th>
<th>Teaching Assistant (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisor encouragement</td>
<td>42%</td>
<td>25%</td>
<td>44%</td>
<td>57%</td>
<td>0%</td>
<td>63%</td>
</tr>
<tr>
<td>Like the applications of machine learning</td>
<td>46%</td>
<td>50%</td>
<td>50%</td>
<td>39%</td>
<td>100%</td>
<td>75%</td>
</tr>
<tr>
<td>Had nothing better to do with my time this summer</td>
<td>31%</td>
<td>30%</td>
<td>50%</td>
<td>17%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Peers were applying too</td>
<td>8%</td>
<td>20%</td>
<td>0%</td>
<td>4%</td>
<td>25%</td>
<td>13%</td>
</tr>
<tr>
<td>Curious to know what the Machine Learning was about</td>
<td>69%</td>
<td>65%</td>
<td>81%</td>
<td>65%</td>
<td>25%</td>
<td>38%</td>
</tr>
<tr>
<td>Had done other summer programs and this one looked different</td>
<td>10%</td>
<td>5%</td>
<td>19%</td>
<td>9%</td>
<td>0%</td>
<td>13%</td>
</tr>
<tr>
<td>Might learn something useful for my classes</td>
<td>69%</td>
<td>85%</td>
<td>69%</td>
<td>57%</td>
<td>25%</td>
<td>13%</td>
</tr>
<tr>
<td>Family encouragement</td>
<td>12%</td>
<td>5%</td>
<td>25%</td>
<td>9%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Would be helpful in getting me an internship</td>
<td>85%</td>
<td>85%</td>
<td>94%</td>
<td>78%</td>
<td>75%</td>
<td>38%</td>
</tr>
<tr>
<td>Would be helpful in getting a job</td>
<td>81%</td>
<td>85%</td>
<td>87%</td>
<td>74%</td>
<td>75%</td>
<td>38%</td>
</tr>
<tr>
<td>Would be helpful if/when applying to graduate degree programs</td>
<td>36%</td>
<td>40%</td>
<td>38%</td>
<td>30%</td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>Recruited at my/their school</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
<td>26%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Wanted to learn something new</td>
<td>58%</td>
<td>60%</td>
<td>69%</td>
<td>48%</td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>Wanted to be around others that like the same things I do</td>
<td>25%</td>
<td>35%</td>
<td>37%</td>
<td>9%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Interested in jobs related to machine learning</td>
<td>53%</td>
<td>55%</td>
<td>56%</td>
<td>48%</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>The course would help me/them figure out what to do in the future</td>
<td>56%</td>
<td>50%</td>
<td>63%</td>
<td>57%</td>
<td>25%</td>
<td>13%</td>
</tr>
</tbody>
</table>
Pre and Post Survey Measurement Scales

Students – Several scales were constructed from survey items included in the pre and post survey administrations. These scales included the applied machine learning course objectives and student learning outcomes (SLOs), ABET SLOs, Engineering efficacy, persistence, and career readiness. Overall, reliability estimates were very supportive, ranging from .762 to .956 on the pre and from .781 to .988 at post.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Items</th>
<th>Pre</th>
<th>Post</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied ML Course Units/Topics</td>
<td>39</td>
<td>.939</td>
<td>.988</td>
<td>Confidence in knowledge and ability related to each topic in the course.</td>
</tr>
<tr>
<td>Applied ML SLOs</td>
<td>6</td>
<td>.806</td>
<td>.938</td>
<td>Confidence in knowledge and abilities related to student learning outcomes</td>
</tr>
<tr>
<td>Career Development Units</td>
<td>13</td>
<td>.950</td>
<td>.965</td>
<td>Confidence in knowledge and ability related to career development topics.</td>
</tr>
<tr>
<td>Career Readiness</td>
<td>8</td>
<td>.925</td>
<td>.921</td>
<td>Competencies for Career Readiness – National Association Of Colleges and Employers</td>
</tr>
<tr>
<td>Interest in ML Careers/Jobs</td>
<td>10</td>
<td>.909</td>
<td>.879</td>
<td>Interest in ML-related jobs/careers</td>
</tr>
<tr>
<td>ABET SLOs</td>
<td>11</td>
<td>.946</td>
<td>.972</td>
<td>Confidence in the knowledge and ability related to the ABET SLOs</td>
</tr>
<tr>
<td>Engineering Efficacy</td>
<td></td>
<td></td>
<td></td>
<td>Undergraduate Students' Engineering Self-Efficacy</td>
</tr>
<tr>
<td>General Knowledge and Ability</td>
<td>6</td>
<td>.924</td>
<td>.950</td>
<td></td>
</tr>
<tr>
<td>Engineering Skills</td>
<td>5</td>
<td>.880</td>
<td>.948</td>
<td></td>
</tr>
<tr>
<td>Engineering design</td>
<td>5</td>
<td>.949</td>
<td>.964</td>
<td></td>
</tr>
<tr>
<td>Tinkering Skills</td>
<td>8</td>
<td>.956</td>
<td>.948</td>
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<tr>
<td>Longitudinal Assessment of Engineering Efficacy</td>
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<td>.892</td>
<td>.956</td>
<td>Longitudinal Assessment of Engineering Self-Efficacy</td>
</tr>
<tr>
<td>21st Century Skills</td>
<td>11</td>
<td>.911</td>
<td>.967</td>
<td>Confidence in relation to 21st century skills (e.g. teamwork, communication)</td>
</tr>
<tr>
<td>Intent to Persist</td>
<td>14</td>
<td>.864</td>
<td>.909</td>
<td>Persistence in degree and career</td>
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<tr>
<td>MSLQ-Critical Thinking</td>
<td>5</td>
<td>.821</td>
<td>.876</td>
<td>Critical Thinking skills</td>
</tr>
<tr>
<td>MSLQ-Self-Regulation</td>
<td>12</td>
<td>.762</td>
<td>.889</td>
<td>Self-regulation skills</td>
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<tr>
<td>MSLQ-Peer Learning</td>
<td>3</td>
<td>.797</td>
<td>.781</td>
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</table>
Pre and Post Survey
Measurement Scales

Faculty and Teaching Assistants - Several scales were also constructed from survey items included in the pre and post survey administrations. These scales included parallel versions of some offered to students (applied machine learning course SLO, course topics, career development and career readiness) as well as the Teaching Engineering Efficacy scales for faculty and the GTA Teaching Self-Efficacy Scale (GTA-TSES) and Teaching Assistants Self-Efficacy Scale (TSE) at TAs. Overall, reliability estimates were very supportive with all exceeding .950 on the pre. With the exception of two scales, all reliability estimates exceeded .75 on the posy survey.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Items</th>
<th>Pre</th>
<th>Post</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied ML Course Units/Topics</td>
<td>39</td>
<td>.978</td>
<td>.965</td>
<td>Confidence in knowledge and ability related to each topic in the course.</td>
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<tr>
<td>Applied ML SLOs</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Confidence</td>
<td>6</td>
<td>.993</td>
<td>NA</td>
<td>Confidence related to SLOs</td>
</tr>
<tr>
<td>Alignment with Course</td>
<td>6</td>
<td>NA</td>
<td>.589</td>
<td></td>
</tr>
<tr>
<td>Achievement by Students</td>
<td>6</td>
<td>NA</td>
<td>.848</td>
<td></td>
</tr>
<tr>
<td>Career Development Units</td>
<td>13</td>
<td>.988</td>
<td>.924</td>
<td>Confidence in knowledge and ability related to career development topics.</td>
</tr>
<tr>
<td>Career Readiness</td>
<td>8</td>
<td>.990</td>
<td>.918</td>
<td>Competencies for Career Readiness – National Association Of Colleges and Employers</td>
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<tr>
<td>Faculty- Teaching Engineering Efficacy</td>
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<td></td>
<td></td>
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<tr>
<td>Content Knowledge</td>
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<td>.993</td>
<td>.495</td>
<td>Efficacy in teaching content</td>
</tr>
<tr>
<td>Motivate Students</td>
<td>3</td>
<td>.983</td>
<td>.857</td>
<td>Efficacy to motivate students</td>
</tr>
<tr>
<td>Instructional Strategies</td>
<td>5</td>
<td>.986</td>
<td>.789</td>
<td>Efficacy to use instructional strategies</td>
</tr>
<tr>
<td>Engagement</td>
<td>4</td>
<td>.960</td>
<td>.960</td>
<td>Efficacy to engage students in class</td>
</tr>
<tr>
<td>Graduate Students</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GTA self efficacy scale</td>
<td>22</td>
<td>.991</td>
<td>.979</td>
<td>GTA efficacy related to TA duties</td>
</tr>
<tr>
<td>GTA Efficacy – Learning</td>
<td>11</td>
<td>.962</td>
<td>.987</td>
<td>Efficacy for creating learning environment</td>
</tr>
<tr>
<td>GTA Efficacy - Instructional</td>
<td>7</td>
<td>.930</td>
<td>.967</td>
<td>Efficacy for using instructional strategies</td>
</tr>
</tbody>
</table>
Summary of Daily and Weekly Feedback

Students were provided an opportunity for daily and weekly feedback throughout the course. A summary of these feedback is provided in the following pages. A complete record of their feedback, including specific comments and suggestions made by students, can be found in the Appendix section of this report. A daily feedback opportunity was provided each day through week 4. In weeks 5 to 7, daily feedback was no longer requested on Fridays so students could focus on the weekly feedback request.

**Week 1**
Responses during week 1 were overwhelmingly positive with all items on each day averaging above 3.75 (using a 5-point scale). Students were especially in agreement that instructors demonstrated command of the content and that the teaching assistants were helpful. While the instructors command of content average above 4 each day, students were particularly positive of June 9 (M=4.60) versus June 8 (M=4.16). Overall, students participating from Morgan State less favorably compared to the other two sites. These responses were significantly lower in relation to the helpfulness of the teaching assistants, quality of instruction, perception of instructor’s command of content, being able to keep up with the pace of the instruction and having a good understanding of what was addressed in class.

**Week 2**
The daily feedback was very positive with all but two responses averaging above 4.0 (using a 5-point scale). Comparisons among days did reveal that students reported less understanding and were not as able to keep up with the pace on June 17 compared to the other days. Follow-up comparisons also revealed that students perceived the quality of instruction to be significantly higher on June 16 compared to June 15 or June 17. As with week 1, participants from Morgan State responded less positively, especially in comparison to students participating at the Kentucky site.

**Week 3**
While this week’s daily feedback was generally lower than the previous week, it was positive with all but three responses averaging above 3.5 (using a 5-point scale). Comparisons among days did reveal that students perceived the quality of instruction on June 22 to be significantly better than that of June 24. No significant differences were observed among the three sites this week. Descriptively, students from Morgan State provided the highest ratings in relation to quality of instruction and having a good understanding of what was addressed in class while students at Kentucky were most positive in terms of instructor’s command of the content and helpfulness of the teaching assistants.

**Week 4**
The week’s feedback was most positive at the beginning of the week and generally declined as the week progressed. While all but 2 items averaged above 3.5 for the first 3 days, half of the items on July 1 averaged below 3.5 and one item averaged below 3. Comparisons among days did reveal that students perceived the quality of instruction on July 1 to be significantly lower than the previous 3 days. Students also reported having a significantly better understanding of the material on June 28 versus July 1. While no statistically significant differences were observed among the three sites, students from Kentucky reported the most positive feedback in relation to instructor’s command of content, helpfulness of teaching assistants, overall quality of instruction, being actively engaged and having a good understanding of the day’s class content.

Continued on Page 9
**Weekly Feedback**

**Week 5** - The week’s feedback was generally positive with all items averaging above 3.5. Responses were most positive in relation to the instructors’ command of content knowledge, the helpfulness of the teaching assistants and overall quality of instruction. Comparisons among days did not reveal any significant differences on the feedback items. Statistically significant different were observed when comparing the three sites with the responses from students at Kentucky being highest, especially in terms of the instructors command of the content, helpfulness of the TAs, and being actively engaged in the class.

**Week 6** - The week’s feedback was very positive with all items averaging a response above 4.0. Although comparisons among days did not reveal any statistically significant differences, student responses were especially positive in relation to instructors’ command of content, overall quality of instruction and helpfulness of teaching assistants. Comparisons among the three sites did reveal statistically significant differences for all 6 items with students from the Morgan State site consistently responding less positively.

**Week 7** - While the response rate was low this week, the feedback was very positive with all items generally averaging a response above 4.0. Student responses were especially positive in relation to instructors’ command of content, overall quality of instruction and helpfulness of teaching assistants. Students also indicated that they were actively engaged in class each day with responses averaging from 4.05 (July 21) to 4.40 (July 22). The open-ended comments reflect students’ appreciation for time to work on the capstone project in class this week. Few suggestions for improvement were offered. No comparisons were made among the three sites due to limited response from two of the sites.

Students were provided an opportunity to submit weekly feedback for weeks 1 to 7. More specifically, feedback was requested in relation to the quality of instruction and professional development offered during the week. Students were also asked to indicate the level of confidence they had in their knowledge and skills pertaining the course topics and objectives scheduled to be addressed in class that week.

**Instructional feedback** – In general, feedback related to each week’s instruction was very positive with overall average responses above 4.0 for 5 of the 7 weeks reported. More specifically, students responded most favorably in weeks 1 and 7 and least favorably in weeks 4 and 5. Students consistently indicated that instructors demonstrated command of the content and they would be able to use what they learned in class to complete the course projects with responses to these items averaging above 4.0 each of the seven weeks. In addition, students indicated that they were engaged, what they learned would help them in other courses, help them completed their degree, and prepare for a potential internship with average responses above 4.0 for all by one week (Week 5 – July 5-9). The two items that generally received the lowest response pertained to being able to keep up with the pace and having a good understanding of the week’s content.

**Weekly Professional Development feedback** – Student response to the professional development was also very positive with overall averages ranging from 3.64 in week 6 to 4.34 in week 2. Students indicated each week that the presenter(s) were well-prepared, well-informed, and presentations were well-organized. In weeks 2 and 7, all items averaged above 4.0. These two week PD sessions were of great interest to students, helped them think about potential career opportunities, explore other PD options, prepare for potential internships, improve their preparation for and motivate them to have a successful career in Engineering.
Focus Groups - June 24, 25

Focus groups were conducted with students from each of the three institutions on June 25 and June 25. A sample of 7 students was invited to participate from each institution and each group was comprised of students from the same site for this initial round of focus groups. All focus groups were conducted virtually, using Zoom. The primary purpose of these initial focus groups was to learn more from students about their experiences in the first few weeks of the course. More specifically, students were asked to discuss their experiences in the course thus far and the extent to which their experiences were as they expected. In doing so, students described aspects of the courses that were working well and offered some suggestions for what could be further examined in order to better serve students in the course.

Overall, students indicated that the overall course was “as advertised” as they described it as rigorous, intensive and fast-paced. They described the course environment as very collaborative and consistently indicated that one of the most beneficial aspects of the course has been meeting and working collaboratively with their peers. They generally perceived sessions in which a faculty member was present to be better than those they watched remotely. Some students expressed having greater challenges because of a more limited background and offered helpful suggestions.

Collaborative Environment – Working on projects and problems with peers has been very beneficial. Students describing meeting and working with other students from diverse backgrounds in terms of race, ethnicity, academic major and academic level. In each focus group, students described the opportunities they have to work with their peers have been most valuable. They described learning from each other as students in their groups have different backgrounds and offer different strengths. Several students described this collaborative teamwork experience as one preparing them for the real world in which they would work on projects as part of interdisciplinary teams. The primary suggestion made related to collaboration is that they welcome more, especially opportunities to interact with students from other groups and the other sites. One group described a class in which the instructor integrated activities into the class that allowed students from the different sites to interact and work together. All groups would welcome more cross-site collaboration on projects and one group indicated interest in a “healthy” competition among the sites.

In-person is better than remote – At two sites, the instructional mode was mixed in that students spent approximately half the class days with an instructor at their site and the other half connecting virtually while students at the third site participate virtually every day as the instructor is at one of the other two sites. At both the mixed instructional sites, students described some technical and learner challenges associated with participating in the class virtually. They described technical issues related to being able to hear the instructor clearly or see the board when the video angle is focused on the classroom. If possible, a separate camera angle on the instructor or a mic for the instructor would help with this issue. Another issue they described is that they were less attentive and engaged when there is not an instructor in their room. The TAs are helpful but students described that they behave differently when an instructor is present.

Students at the virtual site described their experience as one in which they often feel disconnected. They indicated that it is difficult to follow remotely and the audio is often on mute when it appears that the instructor is talking with the class.
Instructional Methods - Student comments related to instructional approaches primarily regarded the amount of information covered in a class. Some students indicated that they have some difficulty keeping up as instructors work through many PowerPoint slides and all groups commented on the limited value of PowerPoint slides and a need for time to discuss more examples and applications. Overall, students welcome opportunities for more hands-on experiences and less PowerPoint slides and lectures.

More background would be helpful – Having more experience with programming, statistics and linear Algebra would be beneficial. Several students described that they struggled a bit to learn the necessary programming and other background skills to do the work in a timely manner. They described asking other students in the class and seeking online videos and resources to try and catch up on this ability. Students indicated that having more applied examples, resources, and additional non-graded assignments with feedback would be very helpful.

Course Management and Organization – Students, especially from one group, described the limitations of using Slack to navigate the course assignments, etc. They suggested using learning management systems (LMS) such as Canvas or Blackboard with which students are familiar, especially this past year as they completed most coursework online. There are helpful organizational features within these LMS such as a dashboard that alert participants (students, TAs and instructors) of the course schedule and when upcoming assignments are due. LMS also offer a way to organize course materials and store completed assignments and feedback that might be helpful to review when working on subsequent tasks.

Other Issues
Logistics and Expenses – Several students commented on a need for more advanced, detailed communication about the course/program and the logistics of transportation and enrollment. They described some minor issues arranging for transportation to the site and some students, particularly at one site, described a need to better understand what precise expenses for which they would be responsible.

Coordinated Activities outside of class - While students describing living and working together as a benefit, they also welcomed more coordinated social activities. Many students are not from the area and welcomed suggested and coordinated activities. One group described having optional social events planned (e.g. bowling, movies, dining, etc..) and thought this was a good opportunity for the class to get to know each other outside of the class context.
Instructor and Teaching Assistants - Pre and Post Findings

**Machine Learning Student Learning Outcomes** - Faculty were more confident in helping students meet the desired student learning outcomes, averaging 4 or above on each of them compared to TAs for which just 2 of the 6 SLOs averaged 4.0 or above. Both groups generally believe that the course was aligned with the expected SLOs with 4 of the 6 averaging 4.0 above for each group. The SLO pertaining to communication of technical aspects to an audience with limited background was identified as being least in alignment. Finally, TAs indicated higher levels of student achievement of the SLOs, identifying student ability to investigate, clean and visualize data as well as apply and tune common ML models while faculty most strongly identifying the communication of technical aspects and understanding and framing a problem as a supervised ML problem and

<table>
<thead>
<tr>
<th>ML Course SLO</th>
<th>Pre-Course Confidence</th>
<th>Alignment</th>
<th>Student Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Investigate, clean and visualize data</td>
<td>Faculty (n=4) TA (n=7)</td>
<td>Faculty (n=4) TA (n=5)</td>
<td>Faculty (n=4) TA (n=5)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>4.75 (.50) 4.00 (1.53)</td>
<td>4.75 (.50) 4.60 (.55)</td>
<td>3.50 (.58) 4.20 (.45)</td>
</tr>
<tr>
<td>2- Understand and frame a problem as a supervised machine learning problem including whether it is a regression or classification problem and to incorporate the application</td>
<td>4.50 (.58) 3.86 (1.67)</td>
<td>3.33 (2.08) 4.40 (.55)</td>
<td>3.67 (.58) 4.00 (0.0)</td>
</tr>
<tr>
<td>3- Apply and tune common machine learning (ML) models in Python by making use of multiple ML toolkits</td>
<td>4.25 (.50) 3.71 (1.70)</td>
<td>5.00 (0.0) 4.60 (.55)</td>
<td>3.33 (.58) 4.20 (.45)</td>
</tr>
<tr>
<td>4- Demonstrate the ability to qualitatively and quantitatively evaluate the quality of trained regression and classification models</td>
<td>4.25 (.96) 3.71 (1.60)</td>
<td>4.67 (58) 4.60 (55)</td>
<td>3.00 (0.0) 4.00 (0.0)</td>
</tr>
<tr>
<td>5- Communicate technical concepts (oral and written) for an audience who may have limited technical background</td>
<td>4.25 (.50) 4.00 (1.53)</td>
<td>3.67 (1.15) 3.80 (0.84)</td>
<td>3.67 (.58) 3.80 (.45)</td>
</tr>
<tr>
<td>6- Identify the potential bias in ML models and explain its implications</td>
<td>4.00 (.82) 3.50 (1.76)</td>
<td>5.00 (0.0) 4.00 (.71)</td>
<td>3.00 (0.0) 4.00 (.71)</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5=A great extent)
Faculty and TAs were also asked to indicate the extent to which they confident in helping students acquire the knowledge and ability related to each of the units and topics to be addressed in the Applied Machine Learning Course. Faculty expressed the greatest confidence in helping students with functions, straight line equation, normal distribution properties, clustering, k-means models, probability and statistics and regular expressions. Teaching assistants expressed the most confidence in their ability to help with computer science and functions, followed by the straight line equation, matrix algebra, probability and p-values, visualization of data, and activation functions. At the post, faculty and TAs were asked to indicate the extent to which they were involved with each of the course topics. With the exception of two topics, Data Science and Ethical Consequences of ML, TAS indicated higher levels of involvement.

<table>
<thead>
<tr>
<th>Machine Learning Units and Topics</th>
<th>Faculty - Confidence (n=4)</th>
<th>TAs Confidence (n=7)</th>
<th>Faculty - Involvement (n=2)</th>
<th>TAs Involvement (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Computer Science</td>
<td>4.50</td>
<td>.577</td>
<td>4.83</td>
<td>.408</td>
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<tr>
<td>Python</td>
<td>4.00</td>
<td>.816</td>
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<tr>
<td>Straight Line Equation</td>
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<td>4.43</td>
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<tr>
<td>Functions</td>
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<td>Matrix Algebra</td>
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<td>4.43</td>
<td>.976</td>
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<td>Normal Distribution Properties</td>
<td>4.75</td>
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<td>Hypothesis Testing</td>
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<td>Probability and p-values</td>
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<td>.957</td>
<td>4.43</td>
<td>.787</td>
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<tr>
<td>Data Science</td>
<td>4.50</td>
<td>.577</td>
<td>4.29</td>
<td>.951</td>
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<tr>
<td>Types of Machine Learning (ML) Models</td>
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<td>.577</td>
<td>4.29</td>
<td>.951</td>
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<td>Ethical Consequences of Machine Learning</td>
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<td>.816</td>
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<td>.900</td>
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<tr>
<td>Data Analysis and Manipulation - Colab notebooks</td>
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<td>.816</td>
<td>4.29</td>
<td>.951</td>
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<td>Data Analysis and Manipulation - Panda Series and Panda DataFrames</td>
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<td>.816</td>
<td>4.00</td>
<td>1.155</td>
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### Skills and Knowledge

<table>
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<th>Skill</th>
<th>Scale (1=Not at all, 5= A great extent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision Trees and Random Forest</td>
<td>4.50 .577 4.14 2.00 4.20 .837</td>
</tr>
<tr>
<td>Bayesian Modeling</td>
<td>3.75 1.500 3.71 1.254 1.00 .000 3.60 .894</td>
</tr>
<tr>
<td>Support Vector Machines (SVM)</td>
<td>4.00 1.155 4.17 1.169 1.50 .707 3.80 1.095</td>
</tr>
<tr>
<td>XG Boost</td>
<td>3.75 1.258 4.43 .787 2.00 1.414 3.20 1.483</td>
</tr>
<tr>
<td>Activation Functions</td>
<td>3.75 1.258 4.43 .787 2.00 1.414 3.20 1.483</td>
</tr>
<tr>
<td>Big O</td>
<td>4.50 1.500 3.86 1.215 1.00 .000 3.00 1.225</td>
</tr>
<tr>
<td>Dimensionality Reduction</td>
<td>4.25 1.500 3.86 1.215 1.00 .000 3.00 1.225</td>
</tr>
<tr>
<td>Loss Functions</td>
<td>4.00 1.155 3.86 1.215 1.00 .000 3.20 1.483</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>4.75 1.500 4.14 .690 2.50 2.121 3.80 1.095</td>
</tr>
<tr>
<td>Regular Expressions</td>
<td>4.75 1.500 4.57 .535 3.00 .000 3.00 1.225</td>
</tr>
<tr>
<td>Visualization of data</td>
<td>4.25 .957 4.43 .787 3.00 1.414 4.20 .837</td>
</tr>
<tr>
<td>Acquiring and downloading data</td>
<td>4.50 .577 4.29 .951 3.50 2.121 4.20 .837</td>
</tr>
<tr>
<td>Exploratory data analysis</td>
<td>4.50 .577 4.29 1.113 4.50 .707 4.00 .707</td>
</tr>
<tr>
<td>Regression analysis</td>
<td>4.50 1.000 4.00 1.000 2.50 2.121 4.20 .837</td>
</tr>
<tr>
<td>Using scikit-learn for regression analysis</td>
<td>4.00 .816 4.00 1.414 2.50 2.121 4.00 1.000</td>
</tr>
<tr>
<td>Using TensorFlow</td>
<td>4.00 .816 3.71 1.380 1.50 .707 4.20 1.095</td>
</tr>
<tr>
<td>Binary Classification methods</td>
<td>4.25 .957 4.14 1.215 2.00 1.414 4.00 1.000</td>
</tr>
<tr>
<td>Multiclass Classification</td>
<td>4.25 .957 4.14 1.215 1.50 .707 4.00 1.000</td>
</tr>
<tr>
<td>Image - Video Classification</td>
<td>3.25 1.258 4.29 1.113 2.00 1.414 3.80 .837</td>
</tr>
<tr>
<td>Deep Learning</td>
<td>3.50 1.291 4.29 1.113 3.00 2.828 4.00 .707</td>
</tr>
<tr>
<td>Recurrent Neural Network</td>
<td>4.00 .816 4.29 .951 3.00 2.828 4.20 .837</td>
</tr>
<tr>
<td>Natural Language Processing</td>
<td>3.75 .957 4.00 1.155 3.00 2.828 4.00 1.000</td>
</tr>
<tr>
<td>Transfer Learning</td>
<td>3.50 1.000 4.14 .900 3.00 2.828 4.00 1.000</td>
</tr>
<tr>
<td>Clustering</td>
<td>4.75 .500 4.29 .951 1.00 .000 4.00 1.000</td>
</tr>
<tr>
<td>k-Means models</td>
<td>4.75 .500 4.14 1.215 2.50 2.121 4.00 1.000</td>
</tr>
<tr>
<td>Embedding</td>
<td>3.75 1.258 4.14 .900 2.50 2.121 4.00 1.000</td>
</tr>
<tr>
<td>Decision Trees and Random Forest</td>
<td>4.50 .577 4.14 .900 1.00 .000 3.60 .894</td>
</tr>
<tr>
<td>Bayesian Modeling</td>
<td>3.75 1.500 3.71 1.254 1.00 .000 3.60 .894</td>
</tr>
</tbody>
</table>
Job Search and Career preparation Skills

Career development is a unit with this course and students will be engaged in activities aimed to better prepare students with the skills they need to get a job and begin their career. While faculty expressed greater confidence, both faculty and TAs indicated a moderately high levels of confidence with items generally averaging above 3.5 (using a 5-point scale). Faculty were especially confident in their ability to help students with thing like constructing a resume, giving and receiving feedback, preparing for a job interview, interviewing and preparing a presentation. TAs were most comfortable helping with preparing for a presentation, delivering an oral presentation with confidence and giving, receiving and using feedback. At the end of the course, faculty and TAs were generally less optimistic that they had an impact with TAS expressing higher levels of confidence. Teaching assistants did, however, indicate improved confidence in helping students give and receive feedback, prepare presentations and deliver strong oral presentations.

<table>
<thead>
<tr>
<th></th>
<th>Faculty PRE (n=4)</th>
<th>TAs PRE (n=7)</th>
<th>Faculty POST (n=3)</th>
<th>TAs POST (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Constructing a resume</td>
<td>4.50 .577</td>
<td>3.71 1.496</td>
<td>1.00 .000</td>
<td>2.20 1.304</td>
</tr>
<tr>
<td>Meeting and engaging with professionals in your field</td>
<td>4.50 .577</td>
<td>3.67 1.506</td>
<td>2.00 1.000</td>
<td>2.40 1.342</td>
</tr>
<tr>
<td>Giving feedback to others</td>
<td>4.50 .577</td>
<td>3.86 1.345</td>
<td>1.33 .577</td>
<td>4.00 1.000</td>
</tr>
<tr>
<td>Receiving and using feedback from others</td>
<td>4.25 .500</td>
<td>3.86 1.345</td>
<td>1.67 1.155</td>
<td>4.20 .837</td>
</tr>
<tr>
<td>Working with recruiters or career services related to potential jobs</td>
<td>3.75 .957</td>
<td>3.43 1.397</td>
<td>1.33 .577</td>
<td>2.20 1.304</td>
</tr>
<tr>
<td>Talking with faculty and others about potential internship of job opportunities</td>
<td>4.25 .500</td>
<td>3.71 1.496</td>
<td>2.33 1.528</td>
<td>3.60 .548</td>
</tr>
<tr>
<td>Preparing application materials for an internship or job</td>
<td>4.25 .500</td>
<td>3.71 1.380</td>
<td>1.67 1.155</td>
<td>2.20 1.095</td>
</tr>
<tr>
<td>Preparing for a job interview</td>
<td>4.50 .577</td>
<td>3.43 1.397</td>
<td>1.67 1.155</td>
<td>2.20 1.095</td>
</tr>
<tr>
<td>Interviewing for an internship or job</td>
<td>4.50 .577</td>
<td>3.43 1.272</td>
<td>1.67 1.155</td>
<td>2.20 1.095</td>
</tr>
<tr>
<td>Preparing for a presentation</td>
<td>4.75 .500</td>
<td>4.00 1.414</td>
<td>2.00 1.000</td>
<td>4.20 .837</td>
</tr>
<tr>
<td>Delivering a strong oral presentation with confidence</td>
<td>4.25 .500</td>
<td>3.86 1.345</td>
<td>2.00 1.000</td>
<td>4.40 .548</td>
</tr>
<tr>
<td>Learning about sources for potential internships or jobs</td>
<td>4.00 .816</td>
<td>3.43 1.397</td>
<td>2.00 1.732</td>
<td>2.60 .894</td>
</tr>
<tr>
<td>Applying for an internship or job opportunity</td>
<td>4.00 .816</td>
<td>3.57 1.397</td>
<td>1.67 1.155</td>
<td>2.80 1.095</td>
</tr>
</tbody>
</table>

1=Not at all, 5=A great extent
Career Readiness Competencies

Faculty and TAs were asked to indicate their confidence in helping students with the eight competencies of career readiness in the table below. Overall, faculty were more confident in helping students become career ready, but both groups were very confident in their ability with responses to all 8 competencies below averaging above 3.5. While faculty reported less confidence on the post-course survey, TAs confidence to help students in terms of career readiness remained stable or was higher. TAs were especially confident that they helped students with their teamwork, technology, communication and critical thinking skills.

<table>
<thead>
<tr>
<th>Career Readiness Competencies</th>
<th>Faculty - PRE (n=4)</th>
<th>TAs - PRE(n=7)</th>
<th>Faculty - POST (n=3)</th>
<th>TAs - POST(n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Career and Self-Development</strong> - Awareness of strengths and weaknesses and seek relationships with professionals and opportunities to better prepare you for a career.</td>
<td>4.00 .816</td>
<td>3.71 1.380</td>
<td>2.33 1.528</td>
<td>3.60 .548</td>
</tr>
<tr>
<td><strong>Communication</strong> - Able to clearly exchange information, ideas, facts, and perspectives with people inside and outside of my current institution or organization.</td>
<td>4.00 .816</td>
<td>3.71 1.380</td>
<td>2.33 1.528</td>
<td>4.00 .707</td>
</tr>
<tr>
<td><strong>Critical Thinking</strong> - Identify and respond to needs based upon an understanding of the context and a logical analysis of relevant information.</td>
<td>4.25 .957</td>
<td>3.71 1.380</td>
<td>3.67 1.528</td>
<td>4.00 .707</td>
</tr>
<tr>
<td><strong>Equity and Inclusion</strong> - Demonstrate an awareness, attitude, knowledge, and skills required to equitably engage and include people from different cultures.</td>
<td>4.25 .957</td>
<td>3.86 1.464</td>
<td>3.00 2.000</td>
<td>3.80 .447</td>
</tr>
<tr>
<td><strong>Leadership</strong> - Recognize and Capitalize on personal and team strengths to achieve organizational goals.</td>
<td>4.00 .816</td>
<td>3.86 1.464</td>
<td>2.33 1.528</td>
<td>3.80 .837</td>
</tr>
<tr>
<td><strong>Professionalism</strong> - Knowing work environments differ greatly, understand and demonstrate effective work habits, and act in the interest of the larger community and workplace.</td>
<td>4.25 .500</td>
<td>3.86 1.464</td>
<td>2.67 1.528</td>
<td>3.80 .447</td>
</tr>
<tr>
<td><strong>Teamwork</strong> - Build and maintain collaborative relationships to work effectively toward common goals, while appreciating diverse viewpoints and share responsibilities.</td>
<td>4.25 .957</td>
<td>3.86 1.464</td>
<td>2.33 .577</td>
<td>4.20 .837</td>
</tr>
<tr>
<td><strong>Technology</strong> - Understand and leverage technology ethically to enhance efficiency, complete tasks and accomplish goals.</td>
<td>4.25 .500</td>
<td>3.86 1.464</td>
<td>3.33 2.082</td>
<td>4.20 .837</td>
</tr>
</tbody>
</table>
Faculty - Teaching Engineering Self-Efficacy

Faculty responded to items related to their confidence (self-efficacy) in their abilities related to teaching engineering. Their responses are summarized below. In general, faculty indicated they have moderate levels of confidence at the beginning of the course as most items tended to average near or above the scale midpoint of 3. Faculty responded with greatest confidence to items related to engaging students with an overall scale mean of 3.5 on the pre and M=4.58 at the end of the course, followed by Engineering content knowledge (M=3.15 on pre, M=4.62 on post), instructional self-efficacy (M=3.10 pre, M=4.33 post) and motivational self-efficacy (M=3.0 pre, M=4.08 post). Responses to all items at the end of the course were higher with just 2 of the 29 items below 4.0.

<table>
<thead>
<tr>
<th>Teaching Engineering Self-Efficacy Scales and Items</th>
<th>Pre (n=4)</th>
<th>Post (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering content knowledge self-efficacy</td>
<td>3.15</td>
<td>4.62</td>
</tr>
<tr>
<td>I can explain the different aspects of the engineering design process.</td>
<td>3.25</td>
<td>4.67</td>
</tr>
<tr>
<td>I can discuss how given criteria affect the outcome of an engineering project.</td>
<td>3.25</td>
<td>4.67</td>
</tr>
<tr>
<td>I can explain engineering concepts well enough to be effective in teaching engineering.</td>
<td>3.50</td>
<td>4.67</td>
</tr>
<tr>
<td>I can assess my students' engineering products</td>
<td>3.25</td>
<td>4.33</td>
</tr>
<tr>
<td>I know how to teach engineering concepts effectively.</td>
<td>3.25</td>
<td>4.33</td>
</tr>
<tr>
<td>I can craft good questions about engineering for my students</td>
<td>3.50</td>
<td>4.67</td>
</tr>
<tr>
<td>I can employ engineering activities in my classroom effectively.</td>
<td>3.25</td>
<td>4.67</td>
</tr>
<tr>
<td>I can discuss how engineering is connected to students' daily lives.</td>
<td>3.25</td>
<td>4.67</td>
</tr>
<tr>
<td>I can spend the time necessary to plan engineering lessons for my class.</td>
<td>2.50</td>
<td>3.67</td>
</tr>
<tr>
<td>I can explain the ways that engineering is used in the world.</td>
<td>3.50</td>
<td>4.67</td>
</tr>
<tr>
<td>I can describe the process of engineering design.</td>
<td>3.25</td>
<td>4.33</td>
</tr>
<tr>
<td>I can select appropriate materials for engineering activities.</td>
<td>3.00</td>
<td>4.33</td>
</tr>
<tr>
<td>I can create engineering activities at the appropriate level for my students.</td>
<td>2.75</td>
<td>4.33</td>
</tr>
<tr>
<td>I stay current in my knowledge of engineering.</td>
<td>3.25</td>
<td>4.33</td>
</tr>
<tr>
<td>I can recognize and appreciate the engineering concepts as they apply to other content areas.</td>
<td>2.75</td>
<td>5.00</td>
</tr>
<tr>
<td>I can guide my students' solution development with the engineering design process.</td>
<td>3.00</td>
<td>4.67</td>
</tr>
</tbody>
</table>

(Continued on Page 18)
## Faculty - Teaching Engineering Self-Efficacy

(Continued from Page 17)

<table>
<thead>
<tr>
<th></th>
<th>Pre (n=4)</th>
<th>Post (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Motivational self-efficacy</strong></td>
<td>3.00</td>
<td>1.66</td>
</tr>
<tr>
<td>I can motivate students who show low interest in the class.</td>
<td>2.75</td>
<td>1.500</td>
</tr>
<tr>
<td>I can increase students' interest in learning engineering</td>
<td>3.25</td>
<td>1.708</td>
</tr>
<tr>
<td>Through engineering activities, I can make students enjoy the class more.</td>
<td>3.00</td>
<td>1.826</td>
</tr>
<tr>
<td><strong>Instructional self-efficacy</strong></td>
<td>3.10</td>
<td>1.41</td>
</tr>
<tr>
<td>I can use a variety of assessment strategies for teaching engineering.</td>
<td>3.00</td>
<td>1.414</td>
</tr>
<tr>
<td>I can adequately assign my students to work at group activities like engineering.</td>
<td>3.25</td>
<td>1.500</td>
</tr>
<tr>
<td>I can plan engineering lessons based on each student's learning level.</td>
<td>3.00</td>
<td>1.414</td>
</tr>
<tr>
<td>I can gauge student comprehension of the engineering materials that I have taught</td>
<td>3.00</td>
<td>1.414</td>
</tr>
<tr>
<td>I can help my students apply their engineering knowledge to real world situations.</td>
<td>3.25</td>
<td>1.500</td>
</tr>
<tr>
<td><strong>Engagement self-efficacy</strong></td>
<td>3.50</td>
<td>1.67</td>
</tr>
<tr>
<td>I can promote a positive attitude toward learning engineering in my students.</td>
<td>3.75</td>
<td>1.893</td>
</tr>
<tr>
<td>I can encourage my students to think creatively during class or other engineering activity.</td>
<td>3.50</td>
<td>1.732</td>
</tr>
<tr>
<td>I can encourage students to think critically when practicing engineering.</td>
<td>3.50</td>
<td>1.732</td>
</tr>
<tr>
<td>I can encourage students to interact and collaborate with each other when working on engineering activities.</td>
<td>3.25</td>
<td>1.708</td>
</tr>
</tbody>
</table>

1 = Not at all, 5 = A great extent
Graduate Teaching Assistant Efficacy

Graduate teaching assistants (GTAs) responded to items reflecting their confidence in creating a positive learning environment and being able to implement effective instructional approaches. TAs indicated increasing high levels of confidence in their abilities related to creating a positive learning environment (M=4.37 on pre and M=4.58 on post) and using instructional strategies (M=4.28 at pre and M=4.51 at post).

<table>
<thead>
<tr>
<th>Learning Environment</th>
<th>Pre (n=8)</th>
<th>Post (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>4.37</td>
<td>.64</td>
<td>4.58</td>
</tr>
<tr>
<td>Promote student participation in class</td>
<td>3.88</td>
<td>1.246</td>
</tr>
<tr>
<td>Make students aware that I have a personal investment in them and their learning</td>
<td>4.38</td>
<td>.518</td>
</tr>
<tr>
<td>Create a positive classroom climate for learning</td>
<td>4.50</td>
<td>.535</td>
</tr>
<tr>
<td>Think of my students as active learners</td>
<td>4.63</td>
<td>.518</td>
</tr>
<tr>
<td>Encourage students to ask questions in class</td>
<td>4.38</td>
<td>.518</td>
</tr>
<tr>
<td>Actively engage students in class activities</td>
<td>4.25</td>
<td>.886</td>
</tr>
<tr>
<td>Promote a positive attitude toward learning in my students</td>
<td>4.38</td>
<td>.744</td>
</tr>
<tr>
<td>Provide support and encouragement for students who are having difficulty</td>
<td>4.50</td>
<td>.756</td>
</tr>
<tr>
<td>Encourage students to interact and work collaboratively with each other</td>
<td>4.38</td>
<td>.744</td>
</tr>
<tr>
<td>Show students respect through my actions</td>
<td>4.50</td>
<td>.756</td>
</tr>
<tr>
<td>Encourage students to take initiative for their own learning</td>
<td>4.38</td>
<td>.744</td>
</tr>
<tr>
<td>Instructional Strategies</td>
<td>4.28</td>
<td>.57</td>
</tr>
<tr>
<td>Appropriately grade student assignments</td>
<td>4.38</td>
<td>.744</td>
</tr>
<tr>
<td>Accurately evaluate student academic ability</td>
<td>4.13</td>
<td>.641</td>
</tr>
<tr>
<td>Prepare instructional materials to be used in class</td>
<td>4.25</td>
<td>.463</td>
</tr>
<tr>
<td>Spend sufficient time planning for class</td>
<td>4.38</td>
<td>.744</td>
</tr>
<tr>
<td>Clearly identify course objectives and expected student outcomes</td>
<td>4.13</td>
<td>.641</td>
</tr>
<tr>
<td>Provide students with detailed feedback about their progress in class</td>
<td>4.37</td>
<td>.744</td>
</tr>
<tr>
<td>Stay current in my knowledge of the content</td>
<td>4.37</td>
<td>.744</td>
</tr>
</tbody>
</table>

1=Not at all, 5=A great extent
GTA Efficacy

The table below summarizes GTA’s level of confidence in their teaching ability. Overall, they expressed moderately high levels of confidence as all items averaged 3.5 or higher and 14 of the 22 items averaged 4.0 or higher at the beginning of the course and all items averaging above 4.0 at the end of the course. At the beginning of the course, TAs were especially confidence in their ability to give lab demonstrations, averaging above 4.5 (M=4.63). However, at the end of the course, they expressed a very high level of confidence in all items with 19 of the 22 averaging above 4.5.

<table>
<thead>
<tr>
<th>Item</th>
<th>Pre (n=8)</th>
<th>Post (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>State clear outcomes for the class</td>
<td>4.25</td>
<td>.463</td>
</tr>
<tr>
<td>Motivate student interest in the class</td>
<td>4.25</td>
<td>.707</td>
</tr>
<tr>
<td>Communicate at a level that matches students’ ability to comprehend</td>
<td>4.25</td>
<td>1.389</td>
</tr>
<tr>
<td>Give a lecture</td>
<td>3.75</td>
<td>1.282</td>
</tr>
<tr>
<td>Give a lab demonstration</td>
<td>4.63</td>
<td>.518</td>
</tr>
<tr>
<td>Respond to student questions during a class, lab or tutorial session</td>
<td>4.25</td>
<td>1.389</td>
</tr>
<tr>
<td>Respond to students’ answers during class, labs or tutorial session.</td>
<td>4.13</td>
<td>1.356</td>
</tr>
<tr>
<td>Plan an organized lecture</td>
<td>3.88</td>
<td>1.246</td>
</tr>
<tr>
<td>Provide constructive written feedback on student assignments</td>
<td>4.00</td>
<td>1.414</td>
</tr>
<tr>
<td>Use technology effectively in class</td>
<td>4.00</td>
<td>1.309</td>
</tr>
<tr>
<td>Assign grades to student work</td>
<td>3.88</td>
<td>1.356</td>
</tr>
<tr>
<td>Manage student disagreements</td>
<td>3.63</td>
<td>1.188</td>
</tr>
<tr>
<td>Model problem solving skills for students</td>
<td>3.88</td>
<td>1.356</td>
</tr>
<tr>
<td>Ask open, stimulating questions to generate discussion</td>
<td>3.88</td>
<td>1.356</td>
</tr>
<tr>
<td>Prepare visual aids for instruction</td>
<td>3.88</td>
<td>1.356</td>
</tr>
<tr>
<td>Arrange for constructive peer feedback and suggestions to improve your teaching</td>
<td>4.00</td>
<td>1.309</td>
</tr>
<tr>
<td>Use gestures or other non-verbal behavior effectively when teaching</td>
<td>4.00</td>
<td>1.309</td>
</tr>
<tr>
<td>Handle disruptive behavior</td>
<td>3.88</td>
<td>1.356</td>
</tr>
<tr>
<td>Encourage student participation in class and other activities</td>
<td>4.00</td>
<td>1.309</td>
</tr>
<tr>
<td>Use student feedback to improve your teaching</td>
<td>4.13</td>
<td>1.356</td>
</tr>
<tr>
<td>Think about your teaching and make necessary changes to improve</td>
<td>4.00</td>
<td>1.309</td>
</tr>
<tr>
<td>Overall, I am confident in my ability to carry out my responsibilities as a teaching assistant</td>
<td>4.00</td>
<td>1.309</td>
</tr>
</tbody>
</table>

1-Not at all, 5=A great extent
Open-ended Questions

Three pre-course open-ended questions were included to gain more information related to what faculty and TAs expected students to learn in the courses, and challenges they anticipated for students and themselves. These responses are summarized in the tables.

<table>
<thead>
<tr>
<th>Faculty (n=2)</th>
<th>TAs (n=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Foundation Machine Learning and Deep Learning · Python programming skills · Understanding what they can and cannot do with machine learning</td>
<td>I expect students to learn from coursework and engage in the program. From the students should walk away with valuable hands-on experience, knowledge from professionals and professors, as well as insight into graduate school, industry, research, and academia.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Describe any challenges you anticipate for students during this course.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty (n=2)</td>
</tr>
<tr>
<td>· I expect students with minimal programming knowledge to fall behind.</td>
</tr>
<tr>
<td>· Programming skills · Deep Learning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Describe any challenges you anticipate for yourself during this course.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty (n=2)</td>
</tr>
<tr>
<td>· I expect it to be challenging to deliver a consistent experience across all sites.</td>
</tr>
<tr>
<td>· Background Diversity of the class</td>
</tr>
</tbody>
</table>
**Post Course Responses**

At the conclusion of the course, faculty and TAs were asked to describe modifications made to the course, challenges experiences and observed student outcomes. Faculty describe the need to supplement the course curriculum with additional information, resources and examples for students and some topics needed more time dedicated to them.

### Please describe ways in which you had to modify the course and what needs to be added

<table>
<thead>
<tr>
<th>Faculty Modifications</th>
<th>Reasons for Modifications</th>
<th>Course Additions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- On many of the topics, additional information regarding how to implement (code) functionalities was needed. In some cases, additional examples were necessary.</td>
<td>1- I would have more modifications, if I had to do it again. I am not sure the degree of modifications I made changes the outcome significantly. With all the above additional parts, here are what students comments (as well as I observed)</td>
<td>1- The students I interacted with needed as much experience and practice with Python as possible. Few of the students I interacted with knew how to use the Google Credits for additional Computational resources. Perhaps a brief tutorial would help with that.</td>
</tr>
<tr>
<td>2- Provide the link between the current lecture and the previous lectures. Recap the previous lectures, especially the lectures that are related to the current lecture. Provide more examples with visualization. When explaining the theory, the corresponding code will be provided to show how to implement that concept. At the end of the lecture, there is a recap section as well as provide the link to the next lecture. For some problems such as regression, classification, etc, provide pseudo code (step-by-step)</td>
<td>2- With recap and linkage lectures: without those, the students feel lost. The additional information aims to systematically understanding the whole picture of the course. With examples and visualization: Aim to understand some new concepts or terminologies much better. With example code to illustrate some theory concept: Aim to know how to implement some new concepts using python/ tensorflow. Help to student be ready for the colab section</td>
<td>2- Deep learning is a hard topic, it will be better to break into 2 weeks instead of 1 week.</td>
</tr>
<tr>
<td>3- I completely redid two of the days. The base lectures were made for in person discussion and it needed more animations and information for discussion over zoom.</td>
<td>3- Hopefully the additions made it easier for students to understand the information.</td>
<td>3- I added embedding information and notes to the NLP lecture.</td>
</tr>
</tbody>
</table>

### Describe any challenges you had working with students during this course

<table>
<thead>
<tr>
<th>Faculty (n=2)</th>
<th>TAs (n=2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• I thought the hybrid format made content delivery a challenge. In addition, I was concerned that there were numerous students who were so behind after 3 weeks (in terms of concepts) that they didn’t benefit from the latter parts of the course. The different levels of experience coming into AMLI was a significant challenge.</td>
<td>• Some of the students are not enough skilled in programming. So it was really challenging to teach them and make understand how to do coding in Tensorflow and other machine learning library.</td>
</tr>
<tr>
<td>• It was difficult to understand what the workload already assigned to students and when they should complete activities.</td>
<td>• program debugging</td>
</tr>
</tbody>
</table>

(Continued on Page 23)
### Post Course Responses

(Continued from Page 22)

#### Describe any challenges you had working with students during this course

**Faculty (n=2)**
- I thought the hybrid format made content delivery a challenge. In addition, I was concerned that there were numerous students who were so behind after 3 weeks (in terms of concepts) that they didn't benefit from the latter parts of the course.
- The different levels of experience coming into AMLI was a significant challenge.

**TAs (n=2)**
- It was difficult to understand what the workload already assigned to students and when they should complete activities.
- Some of the students are not enough skilled in programming. So it was really challenging to teach them and make understand how to do coding in TensorFlow and other machine learning libraries.
- Program debugging

#### Describe specific knowledge or skills that you observed students gain from this course

<table>
<thead>
<tr>
<th>Faculty - no responses</th>
<th>TAs (n=2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Faculty</strong> - no responses</td>
<td><strong>TAs (n=2)</strong></td>
</tr>
</tbody>
</table>

**Faculty (n=1)**
- Working in a team, basic steps of research, which problems can be solved by machine learning/deep learning.
- Programming skills, Python programming, machine learning, team work, critical thinking

**TAs (n=1)**

#### Describe ways in which this summer course experience has benefited you as an instructor and how you will apply what you gained in the coming year.

<table>
<thead>
<tr>
<th>Faculty (n=1)</th>
<th>TAs (n=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Faculty (n=1)</strong></td>
<td><strong>TAs (n=1)</strong></td>
</tr>
</tbody>
</table>

**Faculty (n=1)**
- This was my first in person lecture in a year. It was good talking to many diverse students.

**TAs (n=1)**
- This summer course helped me to improve my communication skill with students which will be beneficial for me in the long run.

#### Please describe what advice you have for other instructors or teaching assistants planning to teach this course.

<table>
<thead>
<tr>
<th>Faculty (n=1)</th>
<th>TA - no response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Faculty (n=1)</strong></td>
<td><strong>TA - no response</strong></td>
</tr>
</tbody>
</table>

**Faculty (n=1)**
- Use the existing material as a starting point not a blue point.
**Student Findings**

**Pre-Course Student Confidence in Machine Learning Student Learning Outcomes**

As might be expected, students were not very confident in their knowledge and abilities related to the Applied Machine Learning Course student learning outcomes prior to course instruction. These will be examined again at the end of the course to determine improvement in their confidence.

<table>
<thead>
<tr>
<th>ML Course SLO</th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigate, clean and visualize data</td>
<td>2.01 .804</td>
<td>2.13 .835</td>
<td>1.53 .551</td>
<td>2.23 .816</td>
</tr>
<tr>
<td>Understand and frame a problem as a supervised machine learning problem including whether it is a regression or classification problem and to incorporate the application requirements</td>
<td>1.72 1.022</td>
<td>1.79 1.084</td>
<td>1.31 .602</td>
<td>1.96 1.147</td>
</tr>
<tr>
<td>Apply and tune common machine learning (ML) models in Python by making use of multiple ML toolkits</td>
<td>1.52 1.013</td>
<td>1.53 .905</td>
<td>1.19 .544</td>
<td>1.74 1.287</td>
</tr>
<tr>
<td>Demonstrate the ability to qualitatively and quantitatively evaluate the quality of trained regression and classification models</td>
<td>1.69 .995</td>
<td>1.58 .692</td>
<td>1.13 .342</td>
<td>2.17 1.267</td>
</tr>
<tr>
<td>Communicate technical concepts (oral and written) for an audience who may have limited technical background</td>
<td>2.71 1.389</td>
<td>2.95 1.433</td>
<td>2.06 1.389</td>
<td>2.96 1.261</td>
</tr>
<tr>
<td>Identify the potential bias in ML models and explain its implications</td>
<td>1.71 .973</td>
<td>1.95 1.224</td>
<td>1.50 .730</td>
<td>1.65 .885</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5=A great extent)
Pre-Course Confidence in ABET Student Learning Outcomes

At the beginning of the course, students did express a moderately high level of confidence in the knowledge and ability related to the ABET student learning outcomes as all responses averaged above the scale midpoint of 3. Students were especially confident in their ability to communicate effectively (M=4.25), understand their professional and ethical responsibilities (M=4.14), recognize the need and ability to engage in professional development/improvement (M=4.08) and work effectively on multidisciplinary teams (M=4.08).

<table>
<thead>
<tr>
<th>ABET SLO</th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply knowledge of mathematics, science and engineering</td>
<td>3.73 .925</td>
<td>3.80 .951</td>
<td>3.31 .873</td>
<td>3.96 .878</td>
</tr>
<tr>
<td>Design and conduct experiments and interpret the resulting data</td>
<td>3.50 .941</td>
<td>3.60 1.046</td>
<td>3.20 1.014</td>
<td>3.61 .783</td>
</tr>
<tr>
<td>Design a system, component, or process to meet desired needs</td>
<td>3.10 1.227</td>
<td>3.15 1.268</td>
<td>2.75 1.125</td>
<td>3.30 1.259</td>
</tr>
<tr>
<td>Work effectively on a multidisciplinary team</td>
<td>4.08 1.164</td>
<td>4.15 1.089</td>
<td>3.94 1.340</td>
<td>4.13 1.140</td>
</tr>
<tr>
<td>Identify, formulate and solve engineering problems</td>
<td>3.56 1.071</td>
<td>3.85 1.089</td>
<td>3.31 1.078</td>
<td>3.48 1.039</td>
</tr>
<tr>
<td>Understand professional and ethical responsibility</td>
<td>4.14 .880</td>
<td>4.20 .768</td>
<td>4.06 .929</td>
<td>4.13 .968</td>
</tr>
<tr>
<td>Communicate effectively</td>
<td>4.25 .939</td>
<td>4.30 .865</td>
<td>4.00 .966</td>
<td>4.39 .988</td>
</tr>
<tr>
<td>Understand the broad impact of engineering solutions in a global, economic, environmental and social context</td>
<td>3.76 1.135</td>
<td>3.70 1.081</td>
<td>3.50 1.211</td>
<td>4.00 1.128</td>
</tr>
<tr>
<td>Recognize the need for and ability to engage in professional development/improvement</td>
<td>4.08 1.022</td>
<td>4.10 1.021</td>
<td>4.00 .894</td>
<td>4.13 1.140</td>
</tr>
<tr>
<td>Understanding and awareness of contemporary issues</td>
<td>3.78 1.131</td>
<td>3.60 1.095</td>
<td>3.69 1.138</td>
<td>4.00 1.168</td>
</tr>
<tr>
<td>Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
<td>3.73 1.172</td>
<td>3.85 1.182</td>
<td>3.38 1.408</td>
<td>3.87 .968</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5=A great extent)
Pre-Course Confidence in Machine Learning Units and Topics

Students were asked to indicate the extent to which they confident in their knowledge and ability related to each of the units and topics to be addressed in the Applied Machine Learning Course. Consistent with their confidence in the overall student learning outcomes, students were not very confident in their knowledge and abilities related to the specific content in the course prior to course instruction. These will be examined again at the end of the course to determine improvement in their confidence.

<table>
<thead>
<tr>
<th>Units and Topics</th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Exploratory data analysis</td>
<td>2.73</td>
<td>1.229</td>
<td>2.90</td>
<td>1.334</td>
</tr>
<tr>
<td>Visualization of data</td>
<td>2.34</td>
<td>1.183</td>
<td>2.35</td>
<td>1.268</td>
</tr>
<tr>
<td>Straight Line Equation</td>
<td>2.74</td>
<td>1.596</td>
<td>3.05</td>
<td>1.701</td>
</tr>
<tr>
<td>Functions</td>
<td>3.34</td>
<td>1.226</td>
<td>3.60</td>
<td>1.536</td>
</tr>
<tr>
<td>Matrix Algebra</td>
<td>2.54</td>
<td>1.104</td>
<td>2.80</td>
<td>1.196</td>
</tr>
<tr>
<td>Normal Distribution Properties</td>
<td>2.61</td>
<td>1.236</td>
<td>2.80</td>
<td>1.322</td>
</tr>
<tr>
<td>Hypothesis Testing</td>
<td>2.84</td>
<td>1.211</td>
<td>2.90</td>
<td>1.334</td>
</tr>
<tr>
<td>Probability and p-values</td>
<td>2.69</td>
<td>1.188</td>
<td>2.70</td>
<td>1.174</td>
</tr>
<tr>
<td>Data Science</td>
<td>1.83</td>
<td>1.045</td>
<td>1.89</td>
<td>1.100</td>
</tr>
<tr>
<td>Types of Machine Learning (ML) Models</td>
<td>1.31</td>
<td>.730</td>
<td>1.35</td>
<td>.489</td>
</tr>
<tr>
<td>Ethical Consequences of Machine Learning</td>
<td>1.53</td>
<td>1.030</td>
<td>1.80</td>
<td>1.196</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Colab notebooks</td>
<td>1.37</td>
<td>.807</td>
<td>1.45</td>
<td>.759</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Panda Series</td>
<td>1.34</td>
<td>.779</td>
<td>1.35</td>
<td>.813</td>
</tr>
<tr>
<td>and Panda DataFrames</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visualization of data</td>
<td>2.12</td>
<td>1.176</td>
<td>2.20</td>
<td>1.196</td>
</tr>
<tr>
<td>Acquiring and downloading data</td>
<td>2.31</td>
<td>1.273</td>
<td>2.26</td>
<td>1.195</td>
</tr>
<tr>
<td>Exploratory data analysis</td>
<td>1.85</td>
<td>1.096</td>
<td>1.95</td>
<td>1.099</td>
</tr>
<tr>
<td>Regression analysis</td>
<td>1.80</td>
<td>1.047</td>
<td>2.00</td>
<td>1.214</td>
</tr>
<tr>
<td>Using scikit-learn for regression analysis</td>
<td>1.15</td>
<td>.407</td>
<td>1.25</td>
<td>.444</td>
</tr>
<tr>
<td>Using Tensorflow</td>
<td>1.09</td>
<td>.283</td>
<td>1.16</td>
<td>.375</td>
</tr>
<tr>
<td>Binary Classification methods</td>
<td>1.44</td>
<td>.702</td>
<td>1.45</td>
<td>.826</td>
</tr>
<tr>
<td>Multiclass Classification</td>
<td>1.30</td>
<td>.658</td>
<td>1.26</td>
<td>.562</td>
</tr>
</tbody>
</table>

(Continued on Page 27)
Pre-Course Confidence in Machine Learning Units and Topics

(Continued from Page 26)

<table>
<thead>
<tr>
<th>Unit / Topic</th>
<th>Scale 1</th>
<th>Scale 2</th>
<th>Scale 3</th>
<th>Scale 4</th>
<th>Scale 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image - Video Classification</td>
<td>1.44</td>
<td>.794</td>
<td>1.50</td>
<td>.827</td>
<td>1.06</td>
</tr>
<tr>
<td>Deep Learning</td>
<td>1.57</td>
<td>1.061</td>
<td>1.47</td>
<td>.964</td>
<td>1.19</td>
</tr>
<tr>
<td>Recurrent Neural Network</td>
<td>1.21</td>
<td>.526</td>
<td>1.16</td>
<td>.375</td>
<td>1.13</td>
</tr>
<tr>
<td>Natural Language Processing</td>
<td>1.31</td>
<td>.598</td>
<td>1.20</td>
<td>.410</td>
<td>1.13</td>
</tr>
<tr>
<td>Transfer Learning</td>
<td>1.31</td>
<td>.730</td>
<td>1.30</td>
<td>.923</td>
<td>1.13</td>
</tr>
<tr>
<td>Clustering</td>
<td>1.46</td>
<td>.857</td>
<td>1.45</td>
<td>.999</td>
<td>1.25</td>
</tr>
<tr>
<td>k-Means models</td>
<td>1.28</td>
<td>.586</td>
<td>1.40</td>
<td>.754</td>
<td>1.13</td>
</tr>
<tr>
<td>Embedding</td>
<td>1.38</td>
<td>.875</td>
<td>1.40</td>
<td>.995</td>
<td>1.38</td>
</tr>
<tr>
<td>Decision Trees and Random Forest</td>
<td>1.29</td>
<td>.617</td>
<td>1.50</td>
<td>.827</td>
<td>1.13</td>
</tr>
<tr>
<td>Bayesian Modeling</td>
<td>1.12</td>
<td>.375</td>
<td>1.25</td>
<td>.550</td>
<td>1.06</td>
</tr>
<tr>
<td>Support Vector Machines (SVM)</td>
<td>1.09</td>
<td>.283</td>
<td>1.15</td>
<td>.366</td>
<td>1.06</td>
</tr>
<tr>
<td>XG Boost</td>
<td>1.07</td>
<td>.254</td>
<td>1.10</td>
<td>.308</td>
<td>1.06</td>
</tr>
<tr>
<td>Activation Functions</td>
<td>1.20</td>
<td>.550</td>
<td>1.15</td>
<td>.489</td>
<td>1.13</td>
</tr>
<tr>
<td>Big O</td>
<td>1.56</td>
<td>.952</td>
<td>1.90</td>
<td>1.165</td>
<td>1.62</td>
</tr>
<tr>
<td>Dimensionality Reduction</td>
<td>1.14</td>
<td>.345</td>
<td>1.20</td>
<td>.410</td>
<td>1.19</td>
</tr>
<tr>
<td>Loss Functions</td>
<td>1.22</td>
<td>.457</td>
<td>1.30</td>
<td>.571</td>
<td>1.13</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>2.62</td>
<td>1.211</td>
<td>2.40</td>
<td>1.231</td>
<td>2.60</td>
</tr>
<tr>
<td>Regular Expressions</td>
<td>2.22</td>
<td>1.378</td>
<td>2.00</td>
<td>1.338</td>
<td>1.94</td>
</tr>
</tbody>
</table>

Scale (1 = Not at all, 5 = A great extent)
Pre-Course Engineering Self-Efficacy

In general, students indicated moderately high levels of confidence related to engineering with all items averaging above the scale midpoint of 3. At the beginning of this course, students were especially confident that they can learn what is taught in their engineering-related courses (M=4.41), do good work in their major classes (M=4.38) and earn good grades in their engineering-related courses (M=4.34).
### Pre-Course Engineering Self-Efficacy

(Continued from Page 28)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Self-Efficacy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can design new things</td>
<td>3.85</td>
<td>.979</td>
<td>3.60</td>
<td>.995</td>
<td>3.81</td>
<td>.981</td>
<td>4.09</td>
<td>.949</td>
</tr>
<tr>
<td>I can identify a design need</td>
<td>3.84</td>
<td>.922</td>
<td>3.50</td>
<td>.946</td>
<td>3.93</td>
<td>.917</td>
<td>4.09</td>
<td>.848</td>
</tr>
<tr>
<td>I can develop design solutions</td>
<td>3.71</td>
<td>1.001</td>
<td>3.35</td>
<td>1.04</td>
<td>3.50</td>
<td>1.033</td>
<td>4.17</td>
<td>.778</td>
</tr>
<tr>
<td>I can evaluate a design</td>
<td>3.68</td>
<td>1.025</td>
<td>3.45</td>
<td>1.05</td>
<td>3.44</td>
<td>1.031</td>
<td>4.04</td>
<td>.928</td>
</tr>
<tr>
<td>I can reorganize changes needed</td>
<td>3.71</td>
<td>.929</td>
<td>3.50</td>
<td>1.00</td>
<td>3.56</td>
<td>.892</td>
<td>4.00</td>
<td>.853</td>
</tr>
<tr>
<td>for a design solution to work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tinkering Self-Efficacy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can work with tools and use them</td>
<td>4.00</td>
<td>1.034</td>
<td>3.85</td>
<td>1.04</td>
<td>3.88</td>
<td>1.088</td>
<td>4.22</td>
<td>.997</td>
</tr>
<tr>
<td>to build things</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can work with tools and use them</td>
<td>3.90</td>
<td>1.078</td>
<td>3.85</td>
<td>.988</td>
<td>3.56</td>
<td>1.263</td>
<td>4.17</td>
<td>.980</td>
</tr>
<tr>
<td>to fix things</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can work with machines</td>
<td>3.61</td>
<td>1.273</td>
<td>3.25</td>
<td>1.58</td>
<td>3.50</td>
<td>1.155</td>
<td>4.00</td>
<td>.951</td>
</tr>
<tr>
<td>I can fix machines</td>
<td>3.20</td>
<td>1.243</td>
<td>2.90</td>
<td>1.37</td>
<td>3.13</td>
<td>1.147</td>
<td>3.52</td>
<td>1.19</td>
</tr>
<tr>
<td>I can manipulate components and</td>
<td>3.36</td>
<td>1.224</td>
<td>3.05</td>
<td>1.39</td>
<td>3.19</td>
<td>1.109</td>
<td>3.77</td>
<td>1.06</td>
</tr>
<tr>
<td>devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can assemble things</td>
<td>3.73</td>
<td>1.243</td>
<td>3.45</td>
<td>1.31</td>
<td>3.50</td>
<td>1.317</td>
<td>4.13</td>
<td>1.04</td>
</tr>
<tr>
<td>I can disassemble things</td>
<td>3.88</td>
<td>1.171</td>
<td>3.84</td>
<td>1.25</td>
<td>3.56</td>
<td>1.263</td>
<td>4.13</td>
<td>1.02</td>
</tr>
<tr>
<td>I can apply technical concepts in</td>
<td>3.80</td>
<td>1.063</td>
<td>3.50</td>
<td>1.19</td>
<td>3.38</td>
<td>1.088</td>
<td>4.35</td>
<td>.64</td>
</tr>
<tr>
<td>engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
Pre-Course Longitudinal Assessment of Engineering Self-Efficacy

Students expressed high levels of efficacy in response to the LAESE items with responses averaging above 4 on 18 of the 23 items. Students most strongly agreed that they would complete their degree at their current institution (M=4.80). They also indicated that they are able to make friends with people with different backgrounds and values (M=4.69), they expect to do well in their courses this year (M=4.59) and a degree in engineering will allow them to get a well-paying job (M=4.59).

<table>
<thead>
<tr>
<th>LAESE Items</th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can relate to people around me in my classes</td>
<td>4.10 .824</td>
<td>4.00 .918</td>
<td>4.06 .998</td>
<td>4.22 .600</td>
</tr>
<tr>
<td>I can succeed in an engineering degree program</td>
<td>4.51 .704</td>
<td>4.70 .470</td>
<td>4.31 .873</td>
<td>4.48 .730</td>
</tr>
<tr>
<td>I have a lot in common with other students in my classes</td>
<td>3.93 .785</td>
<td>3.90 .718</td>
<td>4.00 .816</td>
<td>3.91 .848</td>
</tr>
<tr>
<td>Someone like me can succeed in an engineering career</td>
<td>4.41 .833</td>
<td>4.50 .688</td>
<td>4.06 1.181</td>
<td>4.57 .590</td>
</tr>
<tr>
<td>The other students in my classes share my personal interests</td>
<td>3.75 .779</td>
<td>3.95 .887</td>
<td>3.44 .727</td>
<td>3.78 .671</td>
</tr>
<tr>
<td>I can succeed in an engineering program while NOT having to give up participation in my outside interests (e.g. family, friends, extracurricular activities)</td>
<td>3.76 1.179</td>
<td>3.75 1.333</td>
<td>3.38 1.310</td>
<td>4.04 .878</td>
</tr>
<tr>
<td>I can relate to people around me in my extracurricular activities</td>
<td>3.95 .899</td>
<td>4.00 1.076</td>
<td>3.87 .885</td>
<td>3.96 .767</td>
</tr>
<tr>
<td>I can complete the math requirements for my degree program</td>
<td>4.54 .750</td>
<td>4.75 .444</td>
<td>4.25 1.065</td>
<td>4.57 .662</td>
</tr>
</tbody>
</table>

(Continued on Page 31)
Pre-Course Longitudinal Assessment of Engineering Self-Efficacy

(Continued from Page 30)

<table>
<thead>
<tr>
<th>Item</th>
<th>1 SD</th>
<th>2 D</th>
<th>3 N</th>
<th>4 A</th>
<th>5 SA</th>
<th>6 D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A degree in engineering will allow me to obtain a well paying job</td>
<td>4.59</td>
<td>0.746</td>
<td>4.70</td>
<td>0.470</td>
<td>4.50</td>
<td>0.816</td>
</tr>
<tr>
<td>I will do well in my major courses this year</td>
<td>4.59</td>
<td>0.673</td>
<td>4.60</td>
<td>0.598</td>
<td>4.38</td>
<td>0.719</td>
</tr>
<tr>
<td>I will complete my degree at my current institution</td>
<td>4.80</td>
<td>0.446</td>
<td>4.90</td>
<td>0.308</td>
<td>4.69</td>
<td>0.479</td>
</tr>
<tr>
<td>A degree in engineering will give me the kind of lifestyle I want</td>
<td>4.44</td>
<td>0.856</td>
<td>4.50</td>
<td>0.688</td>
<td>4.25</td>
<td>0.856</td>
</tr>
<tr>
<td>I can make friends with people from different backgrounds and/or values</td>
<td>4.69</td>
<td>0.534</td>
<td>4.75</td>
<td>0.444</td>
<td>4.81</td>
<td>0.403</td>
</tr>
<tr>
<td>Doing well in my classes will increase my sense of self-worth</td>
<td>4.41</td>
<td>0.859</td>
<td>4.45</td>
<td>0.999</td>
<td>4.40</td>
<td>0.737</td>
</tr>
<tr>
<td>I will feel “part of the group” on my job if I enter engineering</td>
<td>3.78</td>
<td>1.052</td>
<td>4.00</td>
<td>0.918</td>
<td>3.50</td>
<td>0.816</td>
</tr>
<tr>
<td>I can complete the science (e.g. physics, chemistry) requirements for my degree</td>
<td>4.60</td>
<td>0.724</td>
<td>4.68</td>
<td>0.478</td>
<td>4.56</td>
<td>1.031</td>
</tr>
<tr>
<td>Taking advance math courses will help keep my career options option</td>
<td>4.25</td>
<td>0.843</td>
<td>4.15</td>
<td>1.040</td>
<td>4.19</td>
<td>0.834</td>
</tr>
<tr>
<td>A degree in engineering will allow me to get a job where I can use my talents and creativity</td>
<td>4.46</td>
<td>0.803</td>
<td>4.50</td>
<td>0.761</td>
<td>4.53</td>
<td>0.640</td>
</tr>
<tr>
<td>I can persist in engineering this academic year.</td>
<td>4.46</td>
<td>0.837</td>
<td>4.75</td>
<td>0.444</td>
<td>4.25</td>
<td>0.775</td>
</tr>
<tr>
<td>I can approach a faculty or staff member to get assistance when needed.</td>
<td>4.20</td>
<td>0.846</td>
<td>4.40</td>
<td>0.821</td>
<td>4.06</td>
<td>0.929</td>
</tr>
<tr>
<td>I can adjust to new work or learning environments</td>
<td>4.47</td>
<td>0.679</td>
<td>4.60</td>
<td>0.598</td>
<td>4.50</td>
<td>0.632</td>
</tr>
<tr>
<td>A degree in engineering will allow me to get a job I like</td>
<td>4.36</td>
<td>0.905</td>
<td>4.65</td>
<td>0.671</td>
<td>4.44</td>
<td>0.629</td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
Pre-Course Confidence in 21st Century Skills

Students expressed high levels of confidence in their ability in their 21st century skills, especially regarding their respect for the differences of their peers (M=4.75), their confidence in working with students from different backgrounds (M=4.69), include others’ perspectives when making decisions (M=4.59).

<table>
<thead>
<tr>
<th>Efficacy – 21st Century Skills</th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am confident I can lead others to accomplish a goal.</td>
<td>4.29 .832</td>
<td>4.25 .716</td>
<td>4.19 .981</td>
<td>4.39 .839</td>
</tr>
<tr>
<td>I am confident I can encourage others to do their best.</td>
<td>4.41 .790</td>
<td>4.55 .605</td>
<td>4.38 .885</td>
<td>4.30 .876</td>
</tr>
<tr>
<td>I am confident I can produce high quality work.</td>
<td>4.51 .704</td>
<td>4.60 .503</td>
<td>4.44 .892</td>
<td>4.48 .730</td>
</tr>
<tr>
<td>I am confident I can respect the differences of my peers.</td>
<td>4.75 .544</td>
<td>4.85 .489</td>
<td>4.63 .619</td>
<td>4.74 .541</td>
</tr>
<tr>
<td>I am confident I can help my peers.</td>
<td>4.31 .856</td>
<td>4.25 .786</td>
<td>4.06 1.124</td>
<td>4.52 .665</td>
</tr>
<tr>
<td>I am confident I can include others’ perspectives when making decisions.</td>
<td>4.59 .619</td>
<td>4.60 .754</td>
<td>4.69 .479</td>
<td>4.52 .593</td>
</tr>
<tr>
<td>I am confident I can make changes when things do not go as planned.</td>
<td>4.47 .751</td>
<td>4.70 .571</td>
<td>4.37 .719</td>
<td>4.35 .885</td>
</tr>
<tr>
<td>I am confident I can set my own learning goals.</td>
<td>4.47 .799</td>
<td>4.60 .503</td>
<td>4.13 1.246</td>
<td>4.57 .590</td>
</tr>
<tr>
<td>I am confident I can manage my time wisely when working on my own.</td>
<td>4.20 .906</td>
<td>4.15 .875</td>
<td>3.94 1.124</td>
<td>4.43 .728</td>
</tr>
<tr>
<td>When I have many assignments, I can choose which ones need to be done first.</td>
<td>4.51 .817</td>
<td>4.65 .489</td>
<td>4.06 1.181</td>
<td>4.70 .635</td>
</tr>
<tr>
<td>I am confident I can work well with students from different backgrounds.</td>
<td>4.69 .595</td>
<td>4.75 .550</td>
<td>4.75 .447</td>
<td>4.61 .722</td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
Pre-Course Persistence

Students generally indicated a strong intention to persist. More specifically, they indicated that they planned to take courses in their major next year (M=4.78) and complete their current degree (M=4.78). They also strongly intended to get a job in their current discipline (M=4.60).

<table>
<thead>
<tr>
<th>Intention to Persist</th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Next year, I plan to take courses in my major discipline</td>
<td>4.78</td>
<td>.559</td>
<td>4.90</td>
<td>.308</td>
</tr>
<tr>
<td>I intend to get my degree in my current major</td>
<td>4.78</td>
<td>.494</td>
<td>4.90</td>
<td>.308</td>
</tr>
<tr>
<td>I am sure that I will continue my education in my major field</td>
<td>4.49</td>
<td>.917</td>
<td>4.75</td>
<td>.550</td>
</tr>
<tr>
<td>I intend to get an advanced degree in my major field</td>
<td>3.86</td>
<td>1.252</td>
<td>3.75</td>
<td>1.517</td>
</tr>
<tr>
<td>I plan to pursue and secure an internship this year</td>
<td>4.29</td>
<td>.929</td>
<td>4.20</td>
<td>1.105</td>
</tr>
<tr>
<td>I intend to get a job in my major field</td>
<td>4.60</td>
<td>.674</td>
<td>4.85</td>
<td>.366</td>
</tr>
<tr>
<td>I can see myself working in my current field for at least 5 years</td>
<td>4.39</td>
<td>.851</td>
<td>4.75</td>
<td>.550</td>
</tr>
<tr>
<td>I plan to devote my career to my current major discipline</td>
<td>4.22</td>
<td>.892</td>
<td>4.65</td>
<td>.587</td>
</tr>
<tr>
<td>I plan to take additional courses related to machine learning</td>
<td>3.93</td>
<td>.944</td>
<td>3.60</td>
<td>.940</td>
</tr>
<tr>
<td>I intend to seek internship opportunities related to machine learning</td>
<td>4.03</td>
<td>.830</td>
<td>3.95</td>
<td>.759</td>
</tr>
<tr>
<td>I am considering changing my major to something more directly related to machine learning</td>
<td>2.73</td>
<td>1.298</td>
<td>2.70</td>
<td>1.455</td>
</tr>
<tr>
<td>I plan to pursue an advanced degree related to machine learning</td>
<td>3.10</td>
<td>1.282</td>
<td>2.70</td>
<td>1.380</td>
</tr>
<tr>
<td>I plan to get a job related to machine learning</td>
<td>3.39</td>
<td>1.034</td>
<td>3.40</td>
<td>.940</td>
</tr>
<tr>
<td>I would like to have a career related to machine learning</td>
<td>3.56</td>
<td>.952</td>
<td>3.55</td>
<td>.945</td>
</tr>
</tbody>
</table>

1=Not TRUE of me , 5=VERY TRUE of me
Pre-Course Confidence in Career Development and Preparation

In general, students expressed confidence in their abilities as they prepare for a career with all but one item averaging above the scale midpoint. They indicated the greatest confidence in their abilities related to having high ethical standards (M=4.36), teamwork skills (M=4.33) and their cultural awareness (M=4.22). Areas in which there is room for improvement included security knowledge (M=2.77), entrepreneurship and intrapreneurship (M=3.22) and data interpretation and visualization (M=3.25).

<table>
<thead>
<tr>
<th>Confidence in Career Development</th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good communication skills</td>
<td>3.96 1.122</td>
<td>4.11 .937</td>
<td>3.81 1.047</td>
<td>3.95 1.356</td>
</tr>
<tr>
<td>Knowledge of physical science and engineering fundamentals</td>
<td>3.24 .999</td>
<td>3.16 .958</td>
<td>3.13 .806</td>
<td>3.40 1.188</td>
</tr>
<tr>
<td>Ability to identify, formulate, and solve engineering problems</td>
<td>3.46 .966</td>
<td>3.47 1.020</td>
<td>3.40 .737</td>
<td>3.50 1.100</td>
</tr>
<tr>
<td>Curiosity and persistent desire for continuous learning</td>
<td>4.16 .898</td>
<td>4.42 .769</td>
<td>4.19 1.047</td>
<td>3.90 .852</td>
</tr>
<tr>
<td>Self-drive and motivation</td>
<td>4.19 .933</td>
<td>4.56 .705</td>
<td>3.94 1.06</td>
<td>4.05 .945</td>
</tr>
<tr>
<td>Cultural awareness in the broad sense (nationality, ethnicity, gender, sexual orient.)</td>
<td>4.22 .786</td>
<td>4.42 .769</td>
<td>4.19 .655</td>
<td>4.05 .887</td>
</tr>
<tr>
<td>Ability to make good economic and business judgements and decisions</td>
<td>3.72 1.054</td>
<td>3.74 1.098</td>
<td>3.44 1.209</td>
<td>3.95 .848</td>
</tr>
<tr>
<td>High ethical standards</td>
<td>4.36 .847</td>
<td>4.42 1.017</td>
<td>4.37 .619</td>
<td>4.30 .865</td>
</tr>
<tr>
<td>Critical thinking skills</td>
<td>4.02 .913</td>
<td>4.11 .937</td>
<td>3.81 .911</td>
<td>4.10 .912</td>
</tr>
<tr>
<td>Willingness to task calculated risks</td>
<td>3.73 1.027</td>
<td>3.89 .994</td>
<td>3.44 1.153</td>
<td>3.80 .951</td>
</tr>
<tr>
<td>Ability to prioritize efficiently</td>
<td>4.07 .900</td>
<td>4.42 .902</td>
<td>3.88 .806</td>
<td>3.90 .912</td>
</tr>
<tr>
<td>Project management</td>
<td>3.80 1.043</td>
<td>4.11 1.150</td>
<td>3.50 1.095</td>
<td>3.75 .851</td>
</tr>
<tr>
<td>Teamwork skills</td>
<td>4.33 .862</td>
<td>4.53 .612</td>
<td>4.25 1.000</td>
<td>4.20 .951</td>
</tr>
<tr>
<td>Entrepreneurship and intrapreneurship</td>
<td>3.22 1.134</td>
<td>3.11 1.150</td>
<td>2.81 1.167</td>
<td>3.65 .988</td>
</tr>
<tr>
<td>Ability to use new technology</td>
<td>4.13 .818</td>
<td>4.26 .806</td>
<td>4.00 .816</td>
<td>4.10 .852</td>
</tr>
<tr>
<td>Applied knowledge of eng core sciences</td>
<td>3.45 1.068</td>
<td>3.32 1.376</td>
<td>3.44 .892</td>
<td>3.60 .883</td>
</tr>
<tr>
<td>Data interpretation and visualization skills</td>
<td>3.25 1.158</td>
<td>3.32 1.250</td>
<td>2.69 1.078</td>
<td>3.65 .988</td>
</tr>
</tbody>
</table>
Pre-Course Job Search and Career Preparation Skills

Career development is a unit with this course and students will be engaged in activities aimed to better prepare them with the skills they need to get a job and begin their career. In response to these items, students indicated a high level of confidence with all items averaging above 3.5 (using a 5-point scale). Students expressed the most confidence in their ability to receive and use feedback from others (M=4.07) and construct a resume (M=4.0). They also indicated confidence in their ability to talk with faculty about potential internships or jobs (M=3.81), and prepare application materials for an internship of job (M=3.81).

<table>
<thead>
<tr>
<th></th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Constructing a resume</td>
<td>4.00</td>
<td>.795</td>
<td>4.20</td>
<td>.951</td>
</tr>
<tr>
<td>Meeting and engaging with professionals in your field</td>
<td>3.62</td>
<td>1.023</td>
<td>3.95</td>
<td>.999</td>
</tr>
<tr>
<td>Giving feedback to others</td>
<td>3.88</td>
<td>.880</td>
<td>3.90</td>
<td>.852</td>
</tr>
<tr>
<td>Receiving and using feedback from others</td>
<td>4.07</td>
<td>.951</td>
<td>4.21</td>
<td>.855</td>
</tr>
<tr>
<td>Working with recruiters or career services related to potential jobs</td>
<td>3.71</td>
<td>.929</td>
<td>3.63</td>
<td>1.012</td>
</tr>
<tr>
<td>Talking with faculty and others about potential internship of job opportunities</td>
<td>3.81</td>
<td>1.017</td>
<td>3.70</td>
<td>1.081</td>
</tr>
<tr>
<td>Preparing application materials for an internship or job</td>
<td>3.81</td>
<td>1.025</td>
<td>4.00</td>
<td>1.106</td>
</tr>
<tr>
<td>Preparing for a job interview</td>
<td>3.64</td>
<td>.931</td>
<td>3.70</td>
<td>1.129</td>
</tr>
<tr>
<td>Interviewing for an internship or job</td>
<td>3.72</td>
<td>.951</td>
<td>3.85</td>
<td>1.137</td>
</tr>
<tr>
<td>Preparing for a presentation you will do</td>
<td>3.76</td>
<td>1.048</td>
<td>3.85</td>
<td>1.182</td>
</tr>
<tr>
<td>Delivering a strong oral presentation with confidence</td>
<td>3.79</td>
<td>1.039</td>
<td>3.80</td>
<td>1.105</td>
</tr>
<tr>
<td>Learning about sources for potential internships or jobs</td>
<td>3.69</td>
<td>.977</td>
<td>3.60</td>
<td>1.142</td>
</tr>
<tr>
<td>Applying for an internship or job opportunity</td>
<td>3.81</td>
<td>.963</td>
<td>3.85</td>
<td>1.137</td>
</tr>
</tbody>
</table>

1=Not at all, 5=A great extent
Pre-Course Career Readiness Competencies

Students were asked to indicate their confidence in relation to the eight competencies of career readiness in the table below. Overall, students expressed confidence in their abilities, especially in terms of teamwork (M=4.32), equity and inclusion (M=4.27) and professionalism (M=4.21).

<table>
<thead>
<tr>
<th>Career Readiness Competencies</th>
<th>Overall Sample (N=59)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=16)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Career and Self-Development</td>
<td>4.04</td>
<td>.801</td>
<td>4.00</td>
<td>.882</td>
</tr>
<tr>
<td>Communication</td>
<td>4.11</td>
<td>1.012</td>
<td>4.21</td>
<td>.918</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>3.96</td>
<td>.906</td>
<td>4.26</td>
<td>.872</td>
</tr>
<tr>
<td>Equity and Inclusion</td>
<td>4.27</td>
<td>.842</td>
<td>4.37</td>
<td>.895</td>
</tr>
<tr>
<td>Leadership</td>
<td>4.05</td>
<td>.915</td>
<td>4.26</td>
<td>.872</td>
</tr>
<tr>
<td>Teamwork</td>
<td>4.32</td>
<td>.834</td>
<td>4.42</td>
<td>.769</td>
</tr>
<tr>
<td>Technology</td>
<td>3.93</td>
<td>1.006</td>
<td>3.95</td>
<td>1.026</td>
</tr>
</tbody>
</table>

1-Not at all, 5=A great extent
Finally, students were asked to indicate their interest in specific careers related to machine learning. Of the 10 careers listed below, students expressed the greatest interest in software engineering (M=3.74), software development (M=3.63), software programming (M=3.58) and machine learning engineering (M=3.58).
Students - Post Survey Findings

Sample - A total of 61 students responded to the post survey. Of these 59 were matched up to their corresponding pre survey. The post results are summarized in this next section followed by a comparison from pre to post for the matched sample of students.

What do you think you gained as a result of your participation in this Applied Machine Learning course?

- Students were asked to identify what they gained from their experiences in this Applied Machine Learning course. Just 10% indicated that they were not sure and 8 of the 10 remaining statements were selected by over 75% of the students completing the course. More specifically, students indicated that they learned applications of machine learning (90%), gained valuable knowledge of machine learning (89%), networked with other students in their discipline (87%), gained experience helpful in getting a job (84%), learned things useful for other courses (82%), gained experience helpful when applying to graduate programs (80%) and established valuable contacts and relationships with faculty in their discipline (79%). In general, a lower percentage of students at Morgan State identified specific benefits and they were more likely to indicate that they were not sure.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I learned about the applications of machine learning</td>
<td>.90</td>
<td>1.00</td>
<td>1.00</td>
<td>.74</td>
</tr>
<tr>
<td>I gained valuable knowledge related to machine learning</td>
<td>.89</td>
<td>1.00</td>
<td>1.00</td>
<td>.70</td>
</tr>
<tr>
<td>I learned something useful for my other classes</td>
<td>.82</td>
<td>.86</td>
<td>.88</td>
<td>.74</td>
</tr>
<tr>
<td>I gained experience that will be helpful in getting me an internship</td>
<td>.90</td>
<td>.90</td>
<td>1.00</td>
<td>.83</td>
</tr>
<tr>
<td>I gained experience that will be helpful in getting a job</td>
<td>.84</td>
<td>.90</td>
<td>.94</td>
<td>.70</td>
</tr>
<tr>
<td>This experience will be helpful if/when applying to graduate degree programs</td>
<td>.80</td>
<td>.86</td>
<td>.88</td>
<td>.70</td>
</tr>
<tr>
<td>I networked with other students in my discipline</td>
<td>.87</td>
<td>.90</td>
<td>1.00</td>
<td>.74</td>
</tr>
<tr>
<td>I became more interested in a career related to machine learning</td>
<td>.61</td>
<td>.57</td>
<td>.76</td>
<td>.52</td>
</tr>
<tr>
<td>The course helped me figure out what I want to do in the future</td>
<td>.67</td>
<td>.67</td>
<td>.88</td>
<td>.52</td>
</tr>
<tr>
<td>I established valuable contacts and relationships with faculty in my discipline</td>
<td>.79</td>
<td>.81</td>
<td>1.00</td>
<td>.61</td>
</tr>
<tr>
<td>I'm not sure</td>
<td>.10</td>
<td>.00</td>
<td>.12</td>
<td>.17</td>
</tr>
</tbody>
</table>
Retrospective Pre-Post Assessment

Students were asked to examine a list of attributes and indicate the extent to which they experienced change since the beginning of the course. Responses were very positive with all averaging above 3.75 and 11 of the 15 above 4.0. Students reported great improvement in their confidence to complete their degree (M=4.2) and earn an advanced degree or get a job after graduation (M=4.3). They also reported great improvement in their communication skills (M=4.23), problem-solving ability (M=4.26) and ability to work effectively with others (M=4.28). Overall, the greatest change (improvement) was reported from Kentucky with an average of 4.38, which was significantly higher than that reported from Morgan State, averaging 3.85.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Interest in machine learning</td>
<td>4.06</td>
<td>.641</td>
<td>4.03</td>
<td>.616</td>
</tr>
<tr>
<td>Belief I will succeed in school</td>
<td>4.11</td>
<td>.877</td>
<td>4.05</td>
<td>.865</td>
</tr>
<tr>
<td>Awareness of potential careers in machine learning</td>
<td>4.10</td>
<td>.768</td>
<td>4.19</td>
<td>.680</td>
</tr>
<tr>
<td>Ability to work effectively with others</td>
<td>4.28</td>
<td>.777</td>
<td>4.19</td>
<td>.750</td>
</tr>
<tr>
<td>Communication skills</td>
<td>4.23</td>
<td>.716</td>
<td>4.24</td>
<td>.700</td>
</tr>
<tr>
<td>Leadership ability</td>
<td>4.08</td>
<td>.787</td>
<td>4.10</td>
<td>.831</td>
</tr>
<tr>
<td>Ability to think of creative solutions to real issues</td>
<td>4.07</td>
<td>.854</td>
<td>4.05</td>
<td>.805</td>
</tr>
<tr>
<td>Time management skills</td>
<td>3.89</td>
<td>.755</td>
<td>3.86</td>
<td>.854</td>
</tr>
<tr>
<td>Interest in a ML career</td>
<td>3.82</td>
<td>1.025</td>
<td>3.76</td>
<td>1.091</td>
</tr>
<tr>
<td>Use of effective study skills</td>
<td>3.87</td>
<td>.806</td>
<td>3.67</td>
<td>.730</td>
</tr>
<tr>
<td>Intention to enroll in more ML related courses</td>
<td>3.82</td>
<td>1.049</td>
<td>3.80</td>
<td>.951</td>
</tr>
<tr>
<td>Intention to seek internship or other opportunities related to machine learning</td>
<td>3.85</td>
<td>1.030</td>
<td>3.71</td>
<td>1.056</td>
</tr>
<tr>
<td>Commitment to complete my degree</td>
<td>4.20</td>
<td>.872</td>
<td>4.14</td>
<td>.910</td>
</tr>
<tr>
<td>Confidence that I will get a job or an advanced degree upon graduation</td>
<td>4.30</td>
<td>.869</td>
<td>4.33</td>
<td>.796</td>
</tr>
</tbody>
</table>

Scale (1=Much Worse, 2=Worse, 3=About the same, 4=Better, 5=Much Better)
### Post Course Reflections

At the end of the course, students were asked to reflect on their experiences and indicate their level of agreement with the statements summarized in the table below. Overall, students planned to keep in touch with other students from the course (M=4.51) and valued the residential component (M=4.43). They also established strong relationships with faculty and planned to keep in touch (M=4.23) and believed they were better prepared for the coming year (M=4.28). Finally, getting a stipend was important to them (M=4.41).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was very important to me that I received course credit for this course.</td>
<td>4.09 (.587)</td>
<td>4.14 (.571)</td>
<td>4.34 (.403)</td>
<td>3.84 (.639)</td>
</tr>
<tr>
<td>Getting a stipend was important to me.</td>
<td>4.20 (.980)</td>
<td>4.38 (.740)</td>
<td>4.29 (1.213)</td>
<td>3.96 (.976)</td>
</tr>
<tr>
<td>I found the residential experience to be very enjoyable.</td>
<td>4.43 (.784)</td>
<td>4.67 (.577)</td>
<td>4.71 (.470)</td>
<td>4.00 (.953)</td>
</tr>
<tr>
<td>I would enroll in a refresher course if available.</td>
<td>3.79 (1.018)</td>
<td>4.00 (.949)</td>
<td>4.00 (1.000)</td>
<td>3.43 (1.037)</td>
</tr>
<tr>
<td>I am more likely to join a professional organization now.</td>
<td>3.97 (.894)</td>
<td>3.76 (.944)</td>
<td>4.47 (.624)</td>
<td>3.78 (.902)</td>
</tr>
<tr>
<td>I plan to keep in touch with other students I met in this course.</td>
<td>4.51 (.698)</td>
<td>4.62 (.669)</td>
<td>4.71 (.470)</td>
<td>4.26 (.810)</td>
</tr>
<tr>
<td>I established strong relationships with the faculty from this course and will keep in touch.</td>
<td>4.23 (.739)</td>
<td>4.24 (.831)</td>
<td>4.41 (.795)</td>
<td>4.09 (.596)</td>
</tr>
<tr>
<td>I will keep in touch with the teaching assistants from this course.</td>
<td>3.72 (1.002)</td>
<td>3.67 (1.197)</td>
<td>3.88 (.857)</td>
<td>3.65 (.935)</td>
</tr>
<tr>
<td>I plan to continue work on the capstone project from this course.</td>
<td>3.21 (1.213)</td>
<td>3.10 (1.338)</td>
<td>3.65 (1.169)</td>
<td>3.00 (1.087)</td>
</tr>
<tr>
<td>I am interested in other learning opportunities to help me retain what I learned in this course.</td>
<td>4.15 (.928)</td>
<td>4.24 (.944)</td>
<td>4.65 (.493)</td>
<td>3.70 (.974)</td>
</tr>
<tr>
<td>I would recommend other coursework related to machine learning to my peers.</td>
<td>4.16 (.820)</td>
<td>4.10 (.768)</td>
<td>4.71 (.470)</td>
<td>3.83 (.887)</td>
</tr>
<tr>
<td>I will be better prepared for the coming year after completing this course.</td>
<td>4.28 (.819)</td>
<td>4.19 (.814)</td>
<td>4.65 (.606)</td>
<td>4.09 (.900)</td>
</tr>
</tbody>
</table>

Scale: (1=SD, 2=D, 3=N, 4=A, 5=SA)
Confidence in Machine Learning Student Learning Outcomes -

Students indicated moderate to high levels of confidence in their knowledge and abilities related to the Applied Machine Learning Course student learning outcomes, with average responses all above the midpoint, ranging from 3.48 to 3.88. These were all much higher compared to the beginning of the course when responses all averaged below 3, ranging from 1.52 to 2.72. A matched samples comparison will be reported later in this report.

<table>
<thead>
<tr>
<th>ML Course SLO</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>3.63</td>
<td>.935</td>
<td>3.68</td>
<td>1.21</td>
<td>3.71</td>
</tr>
<tr>
<td>Investigate, clean and visualize data</td>
<td>3.88</td>
<td>1.059</td>
<td>3.71</td>
<td>1.231</td>
</tr>
<tr>
<td>Understand and frame a problem as a supervised machine learning problem</td>
<td>3.57</td>
<td>1.040</td>
<td>3.52</td>
<td>1.209</td>
</tr>
<tr>
<td>including whether it is a regression or classification problem and to incorporate the application requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apply and tune common machine learning (ML) models in Python by making use of multiple ML toolkits</td>
<td>3.48</td>
<td>1.089</td>
<td>3.52</td>
<td>1.327</td>
</tr>
<tr>
<td>Demonstrate the ability to qualitatively and quantitatively evaluate the quality of trained regression and classification models</td>
<td>3.48</td>
<td>1.026</td>
<td>3.62</td>
<td>1.284</td>
</tr>
<tr>
<td>Communicate technical concepts (oral and written) for an audience who may have limited technical background</td>
<td>3.70</td>
<td>1.174</td>
<td>3.76</td>
<td>1.446</td>
</tr>
<tr>
<td>Identify the potential bias in ML models and explain its implications</td>
<td>3.64</td>
<td>1.033</td>
<td>3.95</td>
<td>1.203</td>
</tr>
</tbody>
</table>

Scale (1—Not at all, 5—A great extent)
### Confidence in ABET Student Learning Outcomes

Students were confident in the knowledge and ability related to the ABET student learning outcomes as all responses averaged above 3.75, with 7 of the 11 above 4.0. Students were especially confident in their ability to communicate effectively ($M=4.13$), work on an interdisciplinary team ($M=4.13$), understand their professional and ethical responsibilities ($M=4.13$), understand the broader impact of engineering ($M=4.08$) and understanding and awareness of contemporary issues ($M=4.08$).

<table>
<thead>
<tr>
<th>ABET SLO</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply knowledge of mathematics, science and engineering</td>
<td>4.00</td>
<td>4.03</td>
<td>4.14</td>
<td>4.12</td>
</tr>
<tr>
<td>Design and conduct experiments and interpret the resulting data</td>
<td>3.98</td>
<td>4.10</td>
<td>4.94</td>
<td>4.24</td>
</tr>
<tr>
<td>Design a system, component, or process to meet desired needs</td>
<td>3.82</td>
<td>3.81</td>
<td>1.123</td>
<td>4.12</td>
</tr>
<tr>
<td>Work effectively on a multidisciplinary team</td>
<td>4.13</td>
<td>4.29</td>
<td>.845</td>
<td>4.41</td>
</tr>
<tr>
<td>Identify, formulate and solve engineering problems</td>
<td>3.92</td>
<td>4.00</td>
<td>1.000</td>
<td>4.18</td>
</tr>
<tr>
<td>Understand professional and ethical responsibility</td>
<td>4.13</td>
<td>4.14</td>
<td>1.062</td>
<td>4.47</td>
</tr>
<tr>
<td>Communicate effectively</td>
<td>4.13</td>
<td>4.05</td>
<td>1.071</td>
<td>4.41</td>
</tr>
<tr>
<td>Understand the broad impact of engineering solutions in a global, economic, environmental and social context</td>
<td>4.08</td>
<td>4.00</td>
<td>1.183</td>
<td>4.41</td>
</tr>
<tr>
<td>Recognize the need for and ability to engage in professional development/ improvement</td>
<td>4.07</td>
<td>3.95</td>
<td>1.024</td>
<td>4.59</td>
</tr>
<tr>
<td>Understanding and awareness of contemporary issues</td>
<td>4.08</td>
<td>4.00</td>
<td>1.049</td>
<td>4.53</td>
</tr>
<tr>
<td>Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.</td>
<td>3.92</td>
<td>3.81</td>
<td>1.167</td>
<td>4.29</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5=A great extent)
Confidence in Machine Learning Units and Topics

Students indicated moderate to high levels of confidence in their knowledge and ability related to units and topics to be addressed in the Applied Machine Learning Course with average responses ranging from 2.59 (Dimensionality Reduction) to 3.87 (Visualization of Data). All averages were higher than that reported at the beginning of the course and a pre-post comparison for the overall matched sample is summarized later in this report.

<table>
<thead>
<tr>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Computer Science</td>
<td>3.49</td>
<td>1.20</td>
<td>3.52</td>
</tr>
<tr>
<td>Python</td>
<td>3.51</td>
<td>1.135</td>
<td>3.52</td>
</tr>
<tr>
<td>Straight Line Equation</td>
<td>3.43</td>
<td>1.372</td>
<td>3.33</td>
</tr>
<tr>
<td>Functions</td>
<td>3.73</td>
<td>1.77</td>
<td>3.71</td>
</tr>
<tr>
<td>Matrix Algebra</td>
<td>3.31</td>
<td>1.162</td>
<td>3.48</td>
</tr>
<tr>
<td>Normal Distribution Properties</td>
<td>3.27</td>
<td>1.133</td>
<td>3.30</td>
</tr>
<tr>
<td>Hypothesis Testing</td>
<td>3.38</td>
<td>1.106</td>
<td>3.43</td>
</tr>
<tr>
<td>Probability and p-values</td>
<td>3.28</td>
<td>1.121</td>
<td>3.38</td>
</tr>
<tr>
<td>Data Science</td>
<td>3.28</td>
<td>.993</td>
<td>3.38</td>
</tr>
<tr>
<td>Types of Machine Learning (ML) Models</td>
<td>3.39</td>
<td>1.005</td>
<td>3.38</td>
</tr>
<tr>
<td>Ethical Consequences of Machine Learning</td>
<td>3.80</td>
<td>1.062</td>
<td>3.90</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Colab notebooks</td>
<td>3.75</td>
<td>1.150</td>
<td>3.76</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Panda Series and Panda DataFrames</td>
<td>3.75</td>
<td>1.135</td>
<td>3.86</td>
</tr>
<tr>
<td>Visualization of data</td>
<td>3.87</td>
<td>1.087</td>
<td>3.86</td>
</tr>
<tr>
<td>Acquiring and downloading data</td>
<td>3.85</td>
<td>1.138</td>
<td>3.81</td>
</tr>
<tr>
<td>Exploratory data analysis</td>
<td>3.70</td>
<td>1.101</td>
<td>3.62</td>
</tr>
<tr>
<td>Regression analysis</td>
<td>3.49</td>
<td>1.090</td>
<td>3.76</td>
</tr>
<tr>
<td>Using TensorFlow</td>
<td>3.26</td>
<td>1.079</td>
<td>3.33</td>
</tr>
<tr>
<td>Binary Classification methods</td>
<td>3.61</td>
<td>1.100</td>
<td>3.62</td>
</tr>
<tr>
<td>Multiclass Classification</td>
<td>3.36</td>
<td>1.126</td>
<td>3.29</td>
</tr>
</tbody>
</table>

(Continued on Page 44)
## Confidence in Machine Learning Units and Topics

(Continued from Page 43)

<table>
<thead>
<tr>
<th>Unit/Topic</th>
<th>Rating</th>
<th>Confidence</th>
<th>Scale 1=Not at all, 5=A great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image - Video Classification</td>
<td>3.21</td>
<td>1.156</td>
<td>2.78, 998</td>
</tr>
<tr>
<td>Deep Learning</td>
<td>3.20</td>
<td>1.108</td>
<td>2.91, 949</td>
</tr>
<tr>
<td>Recurrent Neural Network</td>
<td>3.11</td>
<td>1.097</td>
<td>2.83, 1.029</td>
</tr>
<tr>
<td>Natural Language Processing</td>
<td>3.02</td>
<td>1.008</td>
<td>2.83, 0.887</td>
</tr>
<tr>
<td>Transfer Learning</td>
<td>2.97</td>
<td>1.025</td>
<td>2.70, 0.974</td>
</tr>
<tr>
<td>Clustering</td>
<td>3.03</td>
<td>1.008</td>
<td>2.78, 0.951</td>
</tr>
<tr>
<td>k-Means models</td>
<td>3.08</td>
<td>0.996</td>
<td>2.87, 0.920</td>
</tr>
<tr>
<td>Embedding</td>
<td>3.02</td>
<td>1.066</td>
<td>2.87, 1.014</td>
</tr>
<tr>
<td>Decision Trees and Random Forest</td>
<td>3.16</td>
<td>1.003</td>
<td>2.91, 0.949</td>
</tr>
<tr>
<td>Bayesian Modeling</td>
<td>2.90</td>
<td>1.091</td>
<td>2.96, 1.107</td>
</tr>
<tr>
<td>Support Vector Machines (SVM)</td>
<td>2.84</td>
<td>1.067</td>
<td>2.78, 1.043</td>
</tr>
<tr>
<td>XG Boost</td>
<td>2.90</td>
<td>1.012</td>
<td>2.87, 1.014</td>
</tr>
<tr>
<td>Activation Functions</td>
<td>3.03</td>
<td>1.169</td>
<td>2.83, 0.887</td>
</tr>
<tr>
<td>Big O</td>
<td>2.72</td>
<td>1.082</td>
<td>2.83, 0.887</td>
</tr>
<tr>
<td>Dimensionality Reduction</td>
<td>2.59</td>
<td>1.101</td>
<td>2.61, 0.988</td>
</tr>
<tr>
<td>Loss Functions</td>
<td>2.75</td>
<td>1.174</td>
<td>2.70, 1.020</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>3.18</td>
<td>1.162</td>
<td>3.13, 1.140</td>
</tr>
<tr>
<td>Regular Expressions</td>
<td>3.05</td>
<td>1.117</td>
<td>3.04, 1.022</td>
</tr>
</tbody>
</table>
Engineering Self-Efficacy

Overall, students indicated high levels of confidence related to engineering with all but 5 of the 24 items averaging above 4.0 (using a 5-point scale. Responses on the post-course survey were also generally higher than those reported at the beginning of the course. At the end of this course, students were especially confident in their general and skill-related abilities. More specifically, they strongly believed that they could learn the content taught in engineering classes (M=4.35), earn good grades in these courses (M=4.34), do good work in engineering courses (M=4.30), solve problems using computers (M=4.28), and analyze data from experiments (M=4.26).

<table>
<thead>
<tr>
<th>Engineering Self-Efficacy</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Self-Efficacy</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>I can master the content in my major courses</td>
<td>4.30</td>
<td>.919</td>
<td>4.38</td>
<td>1.071</td>
</tr>
<tr>
<td>I can master the content in even the most challenging engineering course</td>
<td>4.05</td>
<td>.956</td>
<td>4.14</td>
<td>.964</td>
</tr>
<tr>
<td>I can do good work in my major coursework</td>
<td>4.30</td>
<td>.863</td>
<td>4.24</td>
<td>.995</td>
</tr>
<tr>
<td>I can do an excellent job on engineering-related problems or tasks I am assigned</td>
<td>4.25</td>
<td>.789</td>
<td>4.29</td>
<td>.845</td>
</tr>
<tr>
<td>I can learn the content taught in my engineering-related courses</td>
<td>4.35</td>
<td>.777</td>
<td>4.29</td>
<td>.956</td>
</tr>
<tr>
<td>I can earn good grades in my engineering-related courses</td>
<td>4.34</td>
<td>.929</td>
<td>4.33</td>
<td>1.017</td>
</tr>
<tr>
<td>Engineering Skills Self-Efficacy</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>I can perform experiments independently</td>
<td>4.15</td>
<td>.946</td>
<td>4.05</td>
<td>1.161</td>
</tr>
<tr>
<td>I can analyze data from experiments</td>
<td>4.26</td>
<td>.835</td>
<td>4.24</td>
<td>.889</td>
</tr>
<tr>
<td>I can orally communicate results from experiments</td>
<td>4.23</td>
<td>.938</td>
<td>4.29</td>
<td>1.056</td>
</tr>
<tr>
<td>I can communicate results in written form</td>
<td>4.25</td>
<td>.809</td>
<td>4.29</td>
<td>.902</td>
</tr>
<tr>
<td>I can solve problems using a computer</td>
<td>4.28</td>
<td>.951</td>
<td>4.24</td>
<td>1.091</td>
</tr>
<tr>
<td>Design Self-Efficacy</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>I can design new things</td>
<td>4.08</td>
<td>1.038</td>
<td>3.86</td>
<td>1.236</td>
</tr>
<tr>
<td>I can identify a design need</td>
<td>4.16</td>
<td>.986</td>
<td>3.95</td>
<td>1.203</td>
</tr>
<tr>
<td>I can develop design solutions</td>
<td>4.07</td>
<td>.964</td>
<td>3.95</td>
<td>1.071</td>
</tr>
</tbody>
</table>

(Continued on Page 46)
Engineering Self-Efficacy

(Continued from Page 45)

<table>
<thead>
<tr>
<th>I can evaluate a design</th>
<th>4.03</th>
<th>1.016</th>
<th>4.00</th>
<th>1.183</th>
<th>4.24</th>
<th>.752</th>
<th>3.91</th>
<th>1.041</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can reorganize changes needed for a design solution to work</td>
<td>4.03</td>
<td>.983</td>
<td>4.05</td>
<td>1.203</td>
<td>4.18</td>
<td>.883</td>
<td>3.91</td>
<td>.848</td>
</tr>
<tr>
<td>Tinkering Self-Efficacy</td>
<td>3.91</td>
<td>.941</td>
<td>3.83</td>
<td>1.04</td>
<td>4.11</td>
<td>.911</td>
<td>3.85</td>
<td>.884</td>
</tr>
<tr>
<td>I can work with tools and use them to build things</td>
<td>4.05</td>
<td>.973</td>
<td>3.95</td>
<td>1.071</td>
<td>4.29</td>
<td>.772</td>
<td>3.96</td>
<td>1.022</td>
</tr>
<tr>
<td>I can work with tools and use them to fix things</td>
<td>4.10</td>
<td>1.044</td>
<td>4.05</td>
<td>1.161</td>
<td>4.35</td>
<td>.862</td>
<td>3.96</td>
<td>1.065</td>
</tr>
<tr>
<td>I can work with machines</td>
<td>3.92</td>
<td>1.085</td>
<td>3.71</td>
<td>1.271</td>
<td>4.18</td>
<td>1.015</td>
<td>3.91</td>
<td>.949</td>
</tr>
<tr>
<td>I can fix machines</td>
<td>3.68</td>
<td>1.157</td>
<td>3.60</td>
<td>1.188</td>
<td>3.65</td>
<td>1.272</td>
<td>3.78</td>
<td>1.085</td>
</tr>
<tr>
<td>I can manipulate components and devices</td>
<td>3.74</td>
<td>1.168</td>
<td>3.71</td>
<td>1.189</td>
<td>3.94</td>
<td>1.298</td>
<td>3.61</td>
<td>1.076</td>
</tr>
<tr>
<td>I can assemble things</td>
<td>3.90</td>
<td>1.115</td>
<td>3.71</td>
<td>1.231</td>
<td>4.24</td>
<td>1.200</td>
<td>3.82</td>
<td>.907</td>
</tr>
<tr>
<td>I can disassemble things</td>
<td>3.92</td>
<td>1.085</td>
<td>3.95</td>
<td>1.161</td>
<td>4.06</td>
<td>1.088</td>
<td>3.78</td>
<td>1.043</td>
</tr>
<tr>
<td>I can apply technical concepts in engineering</td>
<td>4.03</td>
<td>.966</td>
<td>4.05</td>
<td>1.024</td>
<td>4.18</td>
<td>.951</td>
<td>3.91</td>
<td>.949</td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
Longitudinal Assessment of Engineering Self-Efficacy

Students maintained high levels of efficacy in response to the LAESE items throughout the course with responses averaging above 4 on 21 of the 23 items. Students most strongly agreed that they were able to make friends with people of different backgrounds (M=4.59), they would complete their degree at their current institution (M=4.58), they were able to adjust to new working environments (M=4.55), and they would succeed in an engineering career (M=4.48). Overall, students from Kentucky reported significantly higher levels of confidence (M=4.39) compared to students from Morgan State (M=4.09).

<table>
<thead>
<tr>
<th>LAESE Items</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can relate to people around me in my classes</td>
<td>4.25 .869</td>
<td>4.33 .913</td>
<td>4.35 .862</td>
<td>4.09 .848</td>
</tr>
<tr>
<td>I can succeed in an engineering degree program</td>
<td>4.36 .684</td>
<td>4.48 .602</td>
<td>4.59 .618</td>
<td>4.09 .733</td>
</tr>
<tr>
<td>I have a lot in common with other students in my classes</td>
<td>4.20 .872</td>
<td>4.14 .964</td>
<td>4.53 .624</td>
<td>4.00 .905</td>
</tr>
<tr>
<td>Someone like me can succeed in an engineering career</td>
<td>4.48 .725</td>
<td>4.57 .676</td>
<td>4.71 .470</td>
<td>4.23 .869</td>
</tr>
<tr>
<td>The other students in my classes share my personal interests</td>
<td>4.17 .867</td>
<td>4.14 .964</td>
<td>4.47 .624</td>
<td>3.95 .899</td>
</tr>
<tr>
<td>I can succeed in an engineering program while NOT having to give up participation in my outside interests (e.g. family, friends, extracurricular activities)</td>
<td>3.95 1.126</td>
<td>4.10 1.221</td>
<td>4.06 1.197</td>
<td>3.73 .985</td>
</tr>
<tr>
<td>I can relate to people around me in my extracurricular activities</td>
<td>4.18 .813</td>
<td>4.29 .784</td>
<td>4.41 .618</td>
<td>3.91 .921</td>
</tr>
<tr>
<td>I can complete the math requirements for my degree program,</td>
<td>4.38 .783</td>
<td>4.57 .676</td>
<td>4.35 .862</td>
<td>4.23 .813</td>
</tr>
<tr>
<td>Doing well in math will enhance my career/job opportunities</td>
<td>4.32 .792</td>
<td>4.29 .845</td>
<td>4.59 .507</td>
<td>4.14 .889</td>
</tr>
<tr>
<td>A degree in engineering will allow me to obtain a well paying job</td>
<td>4.48 .725</td>
<td>4.62 .669</td>
<td>4.71 .470</td>
<td>4.18 .853</td>
</tr>
<tr>
<td>I will do well in my major courses this year</td>
<td>4.47 .650</td>
<td>4.48 .680</td>
<td>4.71 .470</td>
<td>4.27 .703</td>
</tr>
<tr>
<td>I will complete my degree at my current institution</td>
<td>4.58 .619</td>
<td>4.62 .590</td>
<td>4.76 .437</td>
<td>4.41 .734</td>
</tr>
<tr>
<td>A degree in engineering will give me the kind of lifestyle I want</td>
<td>4.32 .860</td>
<td>4.43 .746</td>
<td>4.59 .618</td>
<td>4.00 1.04</td>
</tr>
</tbody>
</table>

(Continued on Page 47)
## Longitudinal Assessment of Engineering Self-Efficacy

(Continued from Page 47)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can make friends with people from different backgrounds and/or values</td>
<td>4.59</td>
<td>.668</td>
<td>4.62</td>
<td>.669</td>
<td>4.88</td>
<td>.485</td>
<td>4.35</td>
<td>.714</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doing well in my classes will increase my sense of self-worth</td>
<td>4.28</td>
<td>.859</td>
<td>4.43</td>
<td>.811</td>
<td>4.59</td>
<td>.712</td>
<td>3.91</td>
<td>.900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I will feel &quot;part of the group&quot; on my job if I enter engineering</td>
<td>3.89</td>
<td>.915</td>
<td>3.90</td>
<td>1.044</td>
<td>3.94</td>
<td>.899</td>
<td>3.83</td>
<td>.834</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can complete the science (e.g. physics, chemistry) requirements for my degree</td>
<td>4.39</td>
<td>.737</td>
<td>4.52</td>
<td>.680</td>
<td>4.47</td>
<td>.624</td>
<td>4.22</td>
<td>.850</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taking advance math courses will help keep my career options option</td>
<td>4.21</td>
<td>.897</td>
<td>4.33</td>
<td>.913</td>
<td>4.41</td>
<td>.795</td>
<td>3.96</td>
<td>.928</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A degree in engineering will allow me to get a job where I can use my talents and creativity</td>
<td>4.28</td>
<td>.819</td>
<td>4.43</td>
<td>.746</td>
<td>4.47</td>
<td>.800</td>
<td>4.00</td>
<td>.853</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can persist in engineering this academic year.</td>
<td>4.34</td>
<td>.772</td>
<td>4.48</td>
<td>.750</td>
<td>4.47</td>
<td>.800</td>
<td>4.13</td>
<td>.757</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can approach a faculty or staff member to get assistance when needed.</td>
<td>4.33</td>
<td>.676</td>
<td>4.33</td>
<td>.730</td>
<td>4.47</td>
<td>.624</td>
<td>4.22</td>
<td>.671</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can adjust to new work or learning environments</td>
<td>4.55</td>
<td>.622</td>
<td>4.57</td>
<td>.676</td>
<td>4.76</td>
<td>.437</td>
<td>4.36</td>
<td>.658</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A degree in engineering will allow me to get a job I like</td>
<td>4.42</td>
<td>.743</td>
<td>4.52</td>
<td>.680</td>
<td>4.76</td>
<td>.437</td>
<td>4.05</td>
<td>.844</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
Confidence in 21st Century Skills

Students continued to express high levels of confidence in their ability in their 21st century skills, especially regarding their confidence in respecting the differences in their peers (M=4.48), working with students from different backgrounds (M=4.47), confidence in their ability to help peers (M=4.47), and include others' perspectives when making decisions (M=4.43). Overall, students from Kentucky reported greater confidence in their 21st century skills (M=4.72) compared to students from Morgan State (M=4.19).

<table>
<thead>
<tr>
<th>Efficacy - 21st Century Skills</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am confident I can lead others to accomplish a goal.</td>
<td>4.28 .804</td>
<td>4.33 .856</td>
<td>4.47 .800</td>
<td>4.09 .750</td>
</tr>
<tr>
<td>I am confident I can encourage others to do their best.</td>
<td>4.35 .777</td>
<td>4.33 .730</td>
<td>4.59 .795</td>
<td>4.18 .795</td>
</tr>
<tr>
<td>I am confident I can produce high quality work.</td>
<td>4.43 .673</td>
<td>4.33 .730</td>
<td>4.71 .470</td>
<td>4.32 .716</td>
</tr>
<tr>
<td>I am confident I can respect the differences of my peers.</td>
<td>4.48 .748</td>
<td>4.43 .870</td>
<td>4.88 .332</td>
<td>4.23 .752</td>
</tr>
<tr>
<td>I am confident I can help my peers.</td>
<td>4.47 .681</td>
<td>4.45 .759</td>
<td>4.81 .403</td>
<td>4.23 .685</td>
</tr>
<tr>
<td>I am confident I can include others’ perspectives when making decisions.</td>
<td>4.43 .698</td>
<td>4.38 .805</td>
<td>4.76 .437</td>
<td>4.23 .685</td>
</tr>
<tr>
<td>I am confident I can make changes when things do not go as planned.</td>
<td>4.35 .732</td>
<td>4.33 .856</td>
<td>4.71 .470</td>
<td>4.09 .684</td>
</tr>
<tr>
<td>I am confident I can set my own learning goals.</td>
<td>4.34 .801</td>
<td>4.35 .745</td>
<td>4.65 .702</td>
<td>4.09 .868</td>
</tr>
<tr>
<td>I am confident I can manage my time wisely when working on my own.</td>
<td>4.32 .813</td>
<td>4.05 .921</td>
<td>4.71 .588</td>
<td>4.27 .767</td>
</tr>
<tr>
<td>When I have many assignments, I can choose which ones need to be done first.</td>
<td>4.40 .694</td>
<td>4.29 .845</td>
<td>4.76 .437</td>
<td>4.23 .612</td>
</tr>
<tr>
<td>I am confident I can work well with students from different backgrounds.</td>
<td>4.47 .700</td>
<td>4.48 .750</td>
<td>4.82 .393</td>
<td>4.18 .733</td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
### Persistence

Students continued to indicate a strong intention to persist. More specifically, they indicated that they intended to earn their degree in their current major (M=4.57), planned to pursue an internship in the coming year (M=4.50), take courses in their major next year (M=4.48), continue their education in their major field (M=4.48) and get a job in their current discipline (M=4.45).
Job Search and Career Preparation Skills

Career development was a unit within this course and students were engaged in activities aimed to better prepare them with the skills they need to get a job and begin their career. At the completion of the course, students indicated an increased level of confidence in their job search and career preparation skills. Students expressed the most confidence in their ability to receive and use feedback from others (M=4.13), preparing presentations (M=4.07), delivering strong oral presentations (M=3.95) and meeting and engaging with professionals in their field (M=3.95).
**Career Readiness Competencies**

Students continued to express and improve their confidence in their readiness for a career. Overall, students expressed confidence in their abilities, especially in terms of teamwork (M=4.34), technology (M=4.30), and equity and inclusion (M=4.23).

<table>
<thead>
<tr>
<th>Career Readiness Competencies</th>
<th>Sample (N=61)</th>
<th>(n=21)</th>
<th>(n=17)</th>
<th>State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career Readiness Competencies</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Career and Self-Development - Awareness of strengths and weaknesses and seek relationships with professionals and opportunities to better prepare you for a career.</td>
<td>4.07</td>
<td>.854</td>
<td>4.00</td>
<td>.894</td>
</tr>
<tr>
<td>Communication - Able to clearly exchange information, ideas, facts, and perspectives with people inside and outside of my current institution or organization.</td>
<td>4.10</td>
<td>.768</td>
<td>4.24</td>
<td>.831</td>
</tr>
<tr>
<td>Critical Thinking - Identify and respond to needs based upon an understanding of the context and a logical analysis of relevant information.</td>
<td>4.13</td>
<td>.826</td>
<td>4.29</td>
<td>.845</td>
</tr>
<tr>
<td>Equity and Inclusion - Demonstrate an awareness, attitude, knowledge, and skills required to equitably engage and include people from different cultures.</td>
<td>4.23</td>
<td>.783</td>
<td>4.33</td>
<td>.730</td>
</tr>
<tr>
<td>Leadership - Recognize and Capitalize on personal and team strengths to achieve organizational goals.</td>
<td>4.10</td>
<td>.831</td>
<td>4.19</td>
<td>.873</td>
</tr>
<tr>
<td>Professionalism - Knowing work environments differ greatly, understand and demonstrate effective work habits, and act in the interest of the larger community and workplace.</td>
<td>4.20</td>
<td>.813</td>
<td>4.10</td>
<td>1.044</td>
</tr>
<tr>
<td>Teamwork - Build and maintain collaborative relationships to work effectively toward common goals, while appreciating diverse viewpoints and share responsibilities.</td>
<td>4.34</td>
<td>.750</td>
<td>4.43</td>
<td>1.044</td>
</tr>
<tr>
<td>Technology - Understand and leverage technology ethically to enhance efficiency, complete tasks and accomplish goals.</td>
<td>4.30</td>
<td>.760</td>
<td>4.29</td>
<td>.784</td>
</tr>
</tbody>
</table>

1-Not at all, 5=A great extent
Career Interests

Finally, students expressed increased interest in jobs related to machine learning. Of the 10 careers listed below, students expressed the greatest interest in software engineering (M=3.81), software development (M=3.81), software programming (M=3.66) and artificial intelligence research (M=3.58).

<table>
<thead>
<tr>
<th>Career Interests</th>
<th>Overall Sample (N=61)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Engineer</td>
<td>3.81</td>
<td>3.81</td>
<td>4.00</td>
<td>3.68</td>
</tr>
<tr>
<td>Software Programmer</td>
<td>3.66</td>
<td>3.81</td>
<td>3.69</td>
<td>3.50</td>
</tr>
<tr>
<td>Software Developer</td>
<td>3.81</td>
<td>4.00</td>
<td>3.81</td>
<td>3.64</td>
</tr>
<tr>
<td>Data Scientist</td>
<td>3.41</td>
<td>3.25</td>
<td>3.69</td>
<td>3.36</td>
</tr>
<tr>
<td>Computer Engineer</td>
<td>3.50</td>
<td>3.67</td>
<td>3.13</td>
<td>3.59</td>
</tr>
<tr>
<td>Artificial Intelligence Research Scientist</td>
<td>3.58</td>
<td>3.67</td>
<td>3.62</td>
<td>3.45</td>
</tr>
<tr>
<td>Cloud Engineer</td>
<td>3.31</td>
<td>3.43</td>
<td>3.31</td>
<td>3.18</td>
</tr>
<tr>
<td>Machine Learning Scientist</td>
<td>3.36</td>
<td>3.14</td>
<td>3.88</td>
<td>3.18</td>
</tr>
<tr>
<td>Machine Learning Engineer</td>
<td>3.44</td>
<td>3.24</td>
<td>3.88</td>
<td>3.32</td>
</tr>
<tr>
<td>Big Data Engineer</td>
<td>3.12</td>
<td>3.10</td>
<td>3.06</td>
<td>3.18</td>
</tr>
</tbody>
</table>

1—Not at all interested, 5—Very interested
Pre-Post Comparisons

A matched sample of 59 students was examined to determine the extent to which students changed (improved) from the beginning of the course to the end. The table below summarizes overall pre-post comparisons for 16 survey scales. Overall, improvements were observed on 14 of the 16 examined scales. The results of paired-samples t-tests are also reported. In order to control for Type 1 error, a Bonferroni correction was applied, resulting in an alpha level of .05/16 = .003. Using this corrected alpha level, statistical significance was found in relation to student confidence in their knowledge and skills required for the machine learning topics addressed in the course and the expected student learning outcomes. These effects (Cohen’s d) also exceeded .80, resulting in large effect sizes.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>t</th>
<th>p</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>ML Topics Confidence</td>
<td>59</td>
<td>1.7369</td>
<td>.49536</td>
<td>3.2660</td>
<td>.91228</td>
</tr>
<tr>
<td>ML SLO Confidence</td>
<td>58</td>
<td>2.0080</td>
<td>.80426</td>
<td>3.6040</td>
<td>.93790</td>
</tr>
<tr>
<td>ABET SLO Confidence</td>
<td>59</td>
<td>3.7920</td>
<td>.85698</td>
<td>4.0248</td>
<td>.78110</td>
</tr>
<tr>
<td>ENG Efficacy - General Scale</td>
<td>59</td>
<td>4.1780</td>
<td>.69694</td>
<td>4.2367</td>
<td>.78278</td>
</tr>
<tr>
<td>ENG Efficacy - Skills Scale</td>
<td>59</td>
<td>4.0237</td>
<td>.76211</td>
<td>4.2068</td>
<td>.81872</td>
</tr>
<tr>
<td>ENG Efficacy - Design Scale</td>
<td>59</td>
<td>3.7500</td>
<td>.88945</td>
<td>4.0441</td>
<td>.93297</td>
</tr>
<tr>
<td>ENG Efficacy - Tinkering Scale</td>
<td>59</td>
<td>3.6786</td>
<td>1.03104</td>
<td>3.8780</td>
<td>.93484</td>
</tr>
<tr>
<td>Longitudinal Assessment of Engineering Self-Efficacy</td>
<td>59</td>
<td>4.3257</td>
<td>.47308</td>
<td>4.2973</td>
<td>.56499</td>
</tr>
<tr>
<td>21st Century Skills</td>
<td>58</td>
<td>4.4734</td>
<td>.54989</td>
<td>4.4018</td>
<td>.62985</td>
</tr>
<tr>
<td>Persistence</td>
<td>58</td>
<td>4.0071</td>
<td>.57540</td>
<td>4.0453</td>
<td>.64301</td>
</tr>
<tr>
<td>Career Development Unit Efficacy</td>
<td>58</td>
<td>3.7937</td>
<td>.74777</td>
<td>3.8912</td>
<td>.75190</td>
</tr>
<tr>
<td>ML Career Interest</td>
<td>55</td>
<td>3.4521</td>
<td>.90526</td>
<td>3.4723</td>
<td>.89509</td>
</tr>
<tr>
<td>MSLQ – Critical Thinking</td>
<td>57</td>
<td>3.5895</td>
<td>.81890</td>
<td>3.8316</td>
<td>.71693</td>
</tr>
<tr>
<td>MSLQ – Self-Regulation</td>
<td>57</td>
<td>3.5637</td>
<td>.54014</td>
<td>3.6935</td>
<td>.65693</td>
</tr>
<tr>
<td>MSLQ – Peer Learning</td>
<td>56</td>
<td>3.4345</td>
<td>1.05585</td>
<td>3.8036</td>
<td>.82579</td>
</tr>
</tbody>
</table>
Confidence in Knowledge and Skill – ML Topics

The table below summarizes overall pre-post comparisons for 39 topics from the applied Machine Learning course. Improvements were reported for all topics in order to control for Type 1 error, a Bonferroni correction was applied, resulting in an alpha level of .05/39 = .0013. Using this corrected alpha level, statistical significance was found in relation to 34 of the 39 topics summarized below. Of these 34 statistically significant improvements, 31 resulted in a large effect size.

<table>
<thead>
<tr>
<th>ML Topics</th>
<th>Pre</th>
<th>Post</th>
<th>t</th>
<th>p</th>
<th>Cohen's d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and Skill – ML Topics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science</td>
<td>59</td>
<td>2.73</td>
<td>1.229</td>
<td>3.47</td>
<td>1.120</td>
</tr>
<tr>
<td>Python</td>
<td>59</td>
<td>2.34</td>
<td>1.183</td>
<td>3.53</td>
<td>1.120</td>
</tr>
<tr>
<td>Straight Line Equation</td>
<td>58</td>
<td>2.74</td>
<td>1.596</td>
<td>3.41</td>
<td>1.377</td>
</tr>
<tr>
<td>Functions</td>
<td>58</td>
<td>3.31</td>
<td>1.217</td>
<td>3.71</td>
<td>1.185</td>
</tr>
<tr>
<td>Matrix Algebra</td>
<td>59</td>
<td>2.54</td>
<td>1.104</td>
<td>3.32</td>
<td>1.166</td>
</tr>
<tr>
<td>Normal Distribution Properties</td>
<td>56</td>
<td>2.61</td>
<td>1.246</td>
<td>3.29</td>
<td>1.155</td>
</tr>
<tr>
<td>Hypothesis Testing</td>
<td>57</td>
<td>2.88</td>
<td>1.196</td>
<td>3.37</td>
<td>1.112</td>
</tr>
<tr>
<td>Probability and p-values</td>
<td>57</td>
<td>2.70</td>
<td>1.195</td>
<td>3.28</td>
<td>1.146</td>
</tr>
<tr>
<td>Data Science</td>
<td>57</td>
<td>1.84</td>
<td>1.049</td>
<td>3.26</td>
<td>1.009</td>
</tr>
<tr>
<td>Types of Machine Learning (ML) Models</td>
<td>58</td>
<td>1.31</td>
<td>.730</td>
<td>3.40</td>
<td>1.025</td>
</tr>
<tr>
<td>Ethical Consequences of Machine Learning</td>
<td>58</td>
<td>1.53</td>
<td>1.030</td>
<td>3.79</td>
<td>1.088</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Colab notebooks</td>
<td>59</td>
<td>1.37</td>
<td>.807</td>
<td>3.76</td>
<td>1.165</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Panda Series and Pandas DataFrames</td>
<td>59</td>
<td>1.34</td>
<td>.779</td>
<td>3.76</td>
<td>1.150</td>
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<tr>
<td>Visualization of data</td>
<td>59</td>
<td>2.12</td>
<td>1.176</td>
<td>3.88</td>
<td>1.100</td>
</tr>
<tr>
<td>Acquiring and downloading data</td>
<td>58</td>
<td>2.31</td>
<td>1.273</td>
<td>3.84</td>
<td>1.152</td>
</tr>
<tr>
<td>Exploratory data analysis</td>
<td>59</td>
<td>1.85</td>
<td>1.096</td>
<td>3.71</td>
<td>1.115</td>
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<tr>
<td>Regression analysis</td>
<td>59</td>
<td>1.80</td>
<td>1.047</td>
<td>3.49</td>
<td>1.104</td>
</tr>
<tr>
<td>Using scikit-learn for regression analysis</td>
<td>59</td>
<td>1.15</td>
<td>.407</td>
<td>3.39</td>
<td>1.232</td>
</tr>
<tr>
<td>Using TensorFlow</td>
<td>58</td>
<td>1.09</td>
<td>.283</td>
<td>3.28</td>
<td>1.089</td>
</tr>
</tbody>
</table>

(Continued on Page 56)
## Confidence in Knowledge and Skill - ML Topics

(Continued from Page 55)

<table>
<thead>
<tr>
<th>Topic</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
<th>Z</th>
<th>P</th>
<th>R</th>
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</thead>
<tbody>
<tr>
<td>Binary Classification methods</td>
<td>59</td>
<td>1.44</td>
<td>.702</td>
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<td>1.114</td>
<td>14.529</td>
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<td>1.89</td>
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<tr>
<td>Multiclass Classification</td>
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<td>1.30</td>
<td>.658</td>
<td>3.38</td>
<td>1.121</td>
<td>11.288</td>
<td>&lt;.001</td>
<td>1.51</td>
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<tr>
<td>Image - Video Classification</td>
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<td>1.44</td>
<td>.794</td>
<td>3.20</td>
<td>1.171</td>
<td>9.162</td>
<td>&lt;.001</td>
<td>1.19</td>
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<tr>
<td>Deep Learning</td>
<td>58</td>
<td>1.57</td>
<td>1.061</td>
<td>3.19</td>
<td>1.131</td>
<td>8.665</td>
<td>&lt;.001</td>
<td>1.14</td>
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<tr>
<td>Recurrent Neural Network</td>
<td>57</td>
<td>1.21</td>
<td>.526</td>
<td>3.14</td>
<td>1.109</td>
<td>12.875</td>
<td>&lt;.001</td>
<td>1.71</td>
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<tr>
<td>Natural Language Processing</td>
<td>58</td>
<td>1.31</td>
<td>.598</td>
<td>3.02</td>
<td>1.017</td>
<td>12.668</td>
<td>&lt;.001</td>
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<td>Transfer Learning</td>
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<td>1.32</td>
<td>.736</td>
<td>2.96</td>
<td>1.034</td>
<td>11.931</td>
<td>&lt;.001</td>
<td>1.58</td>
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<td>Clustering</td>
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<td>1.45</td>
<td>.862</td>
<td>3.02</td>
<td>1.017</td>
<td>10.471</td>
<td>&lt;.001</td>
<td>1.38</td>
<td></td>
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<tr>
<td>k-Means models</td>
<td>57</td>
<td>1.26</td>
<td>.583</td>
<td>3.07</td>
<td>1.015</td>
<td>12.875</td>
<td>&lt;.001</td>
<td>1.71</td>
<td></td>
</tr>
<tr>
<td>Embedding</td>
<td>57</td>
<td>1.39</td>
<td>.881</td>
<td>3.00</td>
<td>1.086</td>
<td>9.639</td>
<td>&lt;.001</td>
<td>1.28</td>
<td></td>
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<tr>
<td>Decision Trees and Random Forest</td>
<td>59</td>
<td>1.29</td>
<td>.617</td>
<td>3.15</td>
<td>1.014</td>
<td>12.772</td>
<td>&lt;.001</td>
<td>1.66</td>
<td></td>
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<tr>
<td>Bayesian Modeling</td>
<td>59</td>
<td>1.12</td>
<td>.375</td>
<td>2.88</td>
<td>1.100</td>
<td>12.822</td>
<td>&lt;.001</td>
<td>1.67</td>
<td></td>
</tr>
<tr>
<td>Support Vector Machines (SVM)</td>
<td>58</td>
<td>1.09</td>
<td>.283</td>
<td>2.81</td>
<td>1.083</td>
<td>12.632</td>
<td>&lt;.001</td>
<td>1.66</td>
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<tr>
<td>XG Boost</td>
<td>59</td>
<td>1.07</td>
<td>.254</td>
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<td></td>
</tr>
<tr>
<td>Activation Functions</td>
<td>59</td>
<td>1.20</td>
<td>.550</td>
<td>3.02</td>
<td>1.182</td>
<td>11.940</td>
<td>&lt;.001</td>
<td>1.55</td>
<td></td>
</tr>
<tr>
<td>Big O</td>
<td>59</td>
<td>1.56</td>
<td>.952</td>
<td>2.69</td>
<td>1.087</td>
<td>7.045</td>
<td>&lt;.001</td>
<td>0.917</td>
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<tr>
<td>Dimensionality Reduction</td>
<td>59</td>
<td>1.14</td>
<td>.345</td>
<td>2.56</td>
<td>1.103</td>
<td>10.220</td>
<td>&lt;.001</td>
<td>1.32</td>
<td></td>
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<tr>
<td>Loss Functions</td>
<td>58</td>
<td>1.22</td>
<td>.460</td>
<td>2.72</td>
<td>1.182</td>
<td>10.129</td>
<td>&lt;.001</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Regular Expressions</td>
<td>59</td>
<td>2.22</td>
<td>1.378</td>
<td>3.03</td>
<td>1.129</td>
<td>3.953</td>
<td>&lt;.001</td>
<td>.515</td>
<td></td>
</tr>
</tbody>
</table>
Confidence in ML Student Learning Outcomes

The table below summarizes overall pre-post comparisons for six student learning outcomes expected from the applied Machine Learning course. Improvements were reported for each SLO. Using a correct alpha level of \(0.05/6 = 0.0083\), all changes were statistically significant with 4 of the 6 reaching a large effect size.

<table>
<thead>
<tr>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>Investgate. clean and visualize data</td>
<td>56</td>
</tr>
<tr>
<td>Understand and frame a problem as a supervised machine learning problem including whether it is a regression or classification problem and to incorporate the application requirements</td>
<td>58</td>
</tr>
<tr>
<td>Apply and tune common machine learning (ML) models in Python by making use of multiple ML toolkits</td>
<td>58</td>
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<tr>
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<td>Identify the potential bias in ML models and explain its implications</td>
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Changes Over Time by Site

**University of Arkansas** - A matched sample of 20 students from the University of Arkansas was examined to determine the extent to which students changed (improved) from the beginning of the course to the end. Overall, improvements were observed on 12 of the 16 examined scales. Using this corrected alpha level (.003), statistical significance was found in relation to student confidence in their knowledge and skills required for the machine learning topics addressed in the course and the expected student learning outcomes. These two effects also exceeded .80, resulting in large effect sizes.

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Changes Over Time by Site

University of Kentucky: A matched sample of 16 students from the University of Kentucky was examined to determine the extent to which students changed (improved) from the beginning of the course to the end. Overall, improvements were observed on all 16 examined scales. Using this corrected alpha level (.003), statistical significance was found in relation to student confidence in their knowledge and skills required for the machine learning topics, expected SLOs, ABET SLOs, Engineering Design and Tinkering efficacy, and Peer Learning. These effects also exceeded .80, resulting in large effect sizes.

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Morgan State University - A matched sample of 23 students from the Morgan State University was examined to determine the extent to which students changed (improved) from the beginning of the course to the end. Overall, Morgan State students reported similar post-course responses when compared to their pre responses, increasing on 4 of the 16 summarized below. Using this corrected alpha level (.003), statistical significance was found in relation to student confidence in their knowledge and skills required for the machine learning topics addressed in the course and the expected student learning outcomes. These two differences also exceeded .80, resulting in large effect sizes.

Changes Over Time by Site

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Confidence in Knowledge and Skill – by Institution

The table summarizes overall pre-post comparisons for 39 topics from the applied Machine Learning course for each of the three sites. Improvements were reported for all topics. In order to control for Type 1 error, a Bonferroni correction was applied, resulting in an alpha level of \( \frac{.05}{39} = .0013 \). Using this corrected alpha level, statistical significance was found in relation to 34 of the 39 topics for the overall sample, 28 at Arkansas, 30 at Kentucky and 25 at Morgan State.

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## Confidence in Knowledge and Skill – by Institution

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<td>59</td>
<td>1.763***</td>
<td>20</td>
<td>1.900***</td>
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<tr>
<td>58</td>
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<td>19</td>
<td>1.737***</td>
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<td>58</td>
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<td>1.842***</td>
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<tr>
<td>57</td>
<td>1.807***</td>
<td>15</td>
<td>2.067***</td>
<td>23</td>
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<td><strong>Embedding</strong></td>
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<tr>
<td>57</td>
<td>1.614***</td>
<td>19</td>
<td>1.632***</td>
<td>16</td>
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<td><strong>Decision Trees and Random Forest</strong></td>
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<tr>
<td>59</td>
<td>1.864***</td>
<td>16</td>
<td>2.438***</td>
<td>23</td>
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<td>59</td>
<td>1.763***</td>
<td>20</td>
<td>1.650***</td>
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<td><strong>Support Vector Machines (SVM)</strong></td>
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<td>58</td>
<td>1.724***</td>
<td>20</td>
<td>1.750***</td>
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<td><strong>XG Boost</strong></td>
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<td>59</td>
<td>1.814***</td>
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<td>16</td>
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<td><strong>Activation Functions</strong></td>
<td></td>
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<tr>
<td>59</td>
<td>1.814***</td>
<td>20</td>
<td>1.850***</td>
<td>16</td>
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<tr>
<td><strong>Big O</strong></td>
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<tr>
<td>59</td>
<td>1.136***</td>
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<td>.750*</td>
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<tr>
<td>59</td>
<td>1.424***</td>
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<td>1.500***</td>
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<td><strong>Loss Functions</strong></td>
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<tr>
<td>58</td>
<td>1.500***</td>
<td>15</td>
<td>1.533***</td>
<td>23</td>
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<td><strong>Probability and Statistics</strong></td>
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<tr>
<td>58</td>
<td>.552**</td>
<td>20</td>
<td>.900**</td>
<td>15</td>
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<tr>
<td><strong>Regular Expressions</strong></td>
<td></td>
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<tr>
<td>59</td>
<td>.814***</td>
<td>20</td>
<td>1.000**</td>
<td>16</td>
</tr>
</tbody>
</table>

Confidence scale (1 = Not at all, 5 = A great extent)

*p < .05, **p < .01, ***p < .001
Confidence in ML Student Learning Outcomes by Institution

The table summarizes overall pre-post comparisons for six student learning outcomes expected from the applied Machine Learning course for each site. Improvements were reported for each SLO. Using a correct alpha level of .05/6 = .0083, all changes were statistically significant in the overall sample and at Kentucky with 5 of 6 at Morgan State and 4 of the 6 at Arkansas.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Overall Sample</th>
<th>Arkansas</th>
<th>Kentucky</th>
<th>Morgan State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigate, clean and visualize data</td>
<td>56 1.143***</td>
<td>18  .611</td>
<td>15 2.067***</td>
<td>23  .957**b</td>
</tr>
<tr>
<td>Understand and frame a problem as a supervised machine learning problem including whether it is a regression or classification problem and to incorporate the application requirements</td>
<td>58 1.810***</td>
<td>19 1.684***</td>
<td>16 2.375***</td>
<td>23 1.522***</td>
</tr>
<tr>
<td>Apply and tune common machine learning (ML) models in Python by making use of multiple ML toolkits</td>
<td>58 1.948***</td>
<td>19 2.000***</td>
<td>16 2.438***</td>
<td>23 1.565***</td>
</tr>
<tr>
<td>Demonstrate the ability to qualitatively and quantitatively evaluate the quality of trained regression and classification models</td>
<td>58 1.776***</td>
<td>19 2.053***</td>
<td>16 2.250***</td>
<td>23 1.217***</td>
</tr>
<tr>
<td>Communicate technical concepts (oral and written) for an audience who may have limited technical background</td>
<td>58  .966***</td>
<td>19  .789*</td>
<td>16 1.563***</td>
<td>23  .696*</td>
</tr>
<tr>
<td>Identify the potential bias in ML models and explain its implications</td>
<td>58 1.897***</td>
<td>19 2.000***</td>
<td>16 2.000***</td>
<td>23 1.739***</td>
</tr>
</tbody>
</table>

*a-Confidence scale (1=Not at all, 5=A great extent)
b-p=.006
*p < .05, **p<.01, ***p<.001
Summary and Recommendations

Re-examine student prerequisites-
Students described challenges in learning programming and were limited in other background skills to do the work in a timely manner. They specifically indicated that having more experience with programming, statistics and linear Algebra would be beneficial. Faculty also expected that students with minimal programming knowledge would have difficulty. At the end of the course, one faculty member expressed concern for numerous students who were so behind after 3 weeks that they didn’t benefit from the latter parts of the course and that the different levels of experience coming into AMLI was a significant challenge.

Allow for Curriculum Modification -
The existing curriculum serves as a guide but instructors may need to make modifications to better serve students. Two items, focused on student ability to keep up with the pace and have a good understanding what was addressed in class, received the lowest average daily favorable each week and were among the lowest 3 items on the weekly feedback. Student feedback and focus groups also indicated that more time and examples would be helpful. On the post survey, 3 of 4 faculty described the need to supplement the course curriculum with additional information, resources and examples for students and some topics required more time. Finally, students described having to frequently ask other students in the class or search online videos and resources to try and catch up and having more applied examples, resources, and more non-graded assignments with feedback would be very helpful.

Examine Course Organization Options -
Student focus group comments and ongoing feedback described challenges they had navigating through the course materials and assignments. They suggested using a learning management system (LMS) such as Canvas or Blackboard with which they are students are familiar. There are many built-in organizational features within these LMS such as a dashboard that alert participants (students, TAs and instructors) of the course schedule and when upcoming assignments are due. LMS also offer a way to organize course materials and storage for completed assignments that can be reviewed when preparing for subsequent tasks.

Provide Consistent Instructional approaches across sites-
Two sites had a face-to-face instructor every other day while the third site participated remotely each day. At the end of the course, faculty comments also described the challenges of using a hybrid approach. Instructional delivery options should be consistent across sites. While all sites generally provided very positive feedback related to the instructor’s command of the content and the helpfulness of the teaching assistants, student focus groups and comments reflected the difference experiences. More specifically, students participating remotely described being less attentive and engaged with no instructor in their room and indicated that they would be more engaged if an instructor was present. Students from all sites expressed some challenges related to the technology (audio on mute, limited camera angles) making it more difficult to keep up with the class.

Follow-up Course Participants -
An attempt was made by the evaluator in Fall to follow up on course participants to determine the extent to which they were applying what they experienced in summer to be more confident in coursework, internship opportunities, job interviews and preparation for careers. This attempt did not yield a sufficient response. Program leaders should explore alternative methods to reach out to past participants so they can learn how the course is being applied and what aspects may require revision to better prepare future students.
Resources and References

Applied Machine Learning Course: Instructor Guide


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Sample Characteristics

Sample - A pre-survey was administered to students enrolled in the Applied Machine Learning course during the first week of the course. A total of 62 students responded across the three institutions. The typical student identified as male (74.6%), African American (74.6%), non-Hispanic (73%) and without a disclosed disability (90.5%). Overall, nearly 60% of the students were of junior or senior status and 55.6% reported majoring in Engineering and over 40% expected to earn at least a Masters’ degree.

<table>
<thead>
<tr>
<th>Sample Characteristics</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
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<tbody>
<tr>
<td>Gender (Pronoun)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>He</td>
<td>47 (75.8%)</td>
<td>18 (85.7%)</td>
<td>13 (76.5%)</td>
<td>16 (66.7%)</td>
</tr>
<tr>
<td>She</td>
<td>12 (19.4%)</td>
<td>3 (14.3%)</td>
<td>2 (11.8%)</td>
<td>7 (29.2%)</td>
</tr>
<tr>
<td>They</td>
<td>1 (1.6%)</td>
<td>0</td>
<td>1 (5.9%)</td>
<td>0</td>
</tr>
<tr>
<td>Prefer not to answer</td>
<td>2 (3.2%)</td>
<td>0</td>
<td>1 (5.9%)</td>
<td>1 (4.2%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>46 (74.2%)</td>
<td>14 (66.7%)</td>
<td>10 (58.8%)</td>
<td>22 (91.7%)</td>
</tr>
<tr>
<td>Yes</td>
<td>15 (24.2%)</td>
<td>7 (33.3%)</td>
<td>7 (41.2%)</td>
<td>1 (4.2%)</td>
</tr>
<tr>
<td>Prefer not to answer/no response</td>
<td>1 (1.6%)</td>
<td>0</td>
<td>0</td>
<td>1 (4.2%)</td>
</tr>
<tr>
<td>Racea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Am. Indian/Alaskan Native</td>
<td>3 (4.8%)</td>
<td>0</td>
<td>1 (5.9%)</td>
<td>2 (8.3%)</td>
</tr>
<tr>
<td>Asian or Pacific Islander</td>
<td>1 (1.6%)</td>
<td>1 (4.8%)</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Black or African American</td>
<td>47 (75.8%)</td>
<td>12 (57.1%)</td>
<td>11 (64.7%)</td>
<td>24 (100%)</td>
</tr>
<tr>
<td>Native Hawaiian or Pacific Islander</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>White</td>
<td>12 (19.4%)</td>
<td>6 (26.6%)</td>
<td>5 (29.4%)</td>
<td>1 (4.2%)</td>
</tr>
<tr>
<td>Prefer not to answer</td>
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<td>2 (9.5%)</td>
<td>2 (11.8%)</td>
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<tr>
<td>Other</td>
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<td>Disability</td>
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<td>20 (95.2%)</td>
<td>15 (88.2%)</td>
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<td>Yes</td>
<td>1 (1.6%)</td>
<td>1 (4.8%)</td>
<td>2 (11.8%)</td>
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<td>1 (5.9%)</td>
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<td>19 (30.6%)</td>
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<tr>
<td>JR</td>
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<td>11 (52.4%)</td>
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<td>11 (45.8%)</td>
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<td>SR</td>
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<td>2 (9.5%)</td>
<td>4 (23.5%)</td>
<td>5 (20.8%)</td>
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<tr>
<td>Other/no response</td>
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<td>1 (5.9%)</td>
<td>3 (12.5%)</td>
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<td>Major</td>
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<td>18 (75%)</td>
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<td>22 (35.5%)</td>
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<td>8 (47.1%)</td>
<td>6 (25%)</td>
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<tr>
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<td>2 (3.2%)</td>
<td>1 (4.8%)</td>
<td>1 (5.6%)</td>
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</tbody>
</table>
### Faculty and Teaching Assistants

A total of 12 responses (Faculty = 4, TAs = 8) were recorded for the pre-instruction survey. The typical instructor (faculty and TA) identified as male, Asian, non-Hispanic and not disclosing a disability. There are a total of nine (9) responses on the post-course survey. The typical post-respondent identified as male, non-Hispanic, African American and not disclosing a disability. In addition, participants reported the number of days they were involved in the course.

<table>
<thead>
<tr>
<th>Sample Characteristics</th>
<th>Overall Sample (N=12)</th>
<th>Faculty (n=4)</th>
<th>TAs (n=8)</th>
<th>Overall Sample (N=9)</th>
<th>Faculty (n=4)</th>
<th>TAs (n=5)</th>
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<tbody>
<tr>
<td><strong>Gender (Pronoun)</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>He</td>
<td>9 (75%)</td>
<td>3 (75%)</td>
<td>6 (75%)</td>
<td>5 (55.6%)</td>
<td>2 (50%)</td>
<td>1 (20%)</td>
</tr>
<tr>
<td>She</td>
<td>3 (25%)</td>
<td>1 (25%)</td>
<td>2 (25%)</td>
<td>1 (11.1%)</td>
<td>1 (25%)</td>
<td>0</td>
</tr>
<tr>
<td>They</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prefer not to answer</td>
<td>3 (25%)</td>
<td>2 (25%)</td>
<td>1 (11.1%)</td>
<td>0</td>
<td>1 (20%)</td>
<td>0</td>
</tr>
</tbody>
</table>

| **Hispanic**           |                       |              |           |                      |              |          |
| No                     | 12 (100%)             | 4 (100%)     | 8 (100%)  | 8 (88.9%)            | 4 (100%)     | 4 (80%)  |
| Yes                    | 0                     | 0            | 0         | 0                    | 0            | 0        |
| Prefer not to answer   | 0                     | 0            | 0         | 0                    | 0            | 0        |

| **Race**               |                       |              |           |                      |              |          |
| Am. Indian/Alaskan Native | 0 (0%)              | 0 (0%)      | 0 (0%)   | 0 (0%)               | 0 (0%)      | 0 (0%)   |
| Asian or Pacific Islander | 7 (58.3%)           | 2 (50%)     | 5 (62.5%)| 3 (33.3%)            | 2 (50%)     | 2 (40%)  |
| Black or African American | 4 (33.3%)           | 1 (25%)     | 3 (37.5%)| 4 (44.4%)            | 1 (25%)     | 1 (20%)  |
| Nat Hawaiian or Pac Islander | 0 (0%)             | 0 (0%)      | 0 (0%)   | 0 (0%)               | 0 (0%)      | 0 (0%)   |
| White                  | 1 (8.3%)              | 1 (25%)     | 1 (11.1%)| 2 (22.2%)            | 1 (25%)     | 1 (20%)  |
| Other                  | 0                     | 0           | 0         | 0                    | 0           | 0        |
| Prefer not to answer   | 0                     | 0           | 0         | 0                    | 0           | 0        |

| **Disability**         |                       |              |           |                      |              |          |
| No                     | 12 (100%)             | 4 (100%)     | 8 (100%)  | 5 (55.5%)            | 2 (75%)      | 3 (60%)  |
| Yes                    | 0                     | 0           | 0         | 3 (33.3%)            | 0 (0%)       | 1 (20%)  |
| Prefer not to answer   | 0                     | 0           | 0         | 0                    | 0           | 0        |

<table>
<thead>
<tr>
<th>Participation -Number of Classes</th>
<th>Pre Course Survey</th>
<th>Post-Course Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M=5.5, SD=2.1, Range=3-8</td>
<td>M=31, SD=8.9, Range=20-40</td>
</tr>
</tbody>
</table>
Why did Students Enroll in the Course?

Students expect this Applied Machine Learning course to be valuable for a variety of reasons. In the overall sample, over 50% indicated that they thought they would learn something useful for their classes (60%), were curious to know more about machine learning (60%), just wanted to learn something new (60%), thought the course would be helpful in getting an internship (61%) and getting a job (66%).
### Pre and Post Survey Measurement Scales

#### Students

Several scales were constructed from survey items included in the pre and post survey administrations. These scales included the applied machine learning course objectives and student learning outcomes (SLOs), ABET SLOs, Engineering efficacy, persistence, career readiness and culturally responsive teaching. Overall, reliability estimates were very supportive, ranging from .831 to .965 on the pre administration and from .886 to .983 at post.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Items</th>
<th>Pre</th>
<th>Post</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied ML Course Units/Topics</td>
<td>39</td>
<td>.965</td>
<td>.977</td>
<td>Confidence in knowledge and ability related to each topic in the course.</td>
</tr>
<tr>
<td>Applied ML SLOs</td>
<td>6</td>
<td>.891</td>
<td>.886</td>
<td>Confidence in knowledge and abilities related to student learning outcomes</td>
</tr>
<tr>
<td>Career Development Units</td>
<td>13</td>
<td>.957</td>
<td>.965</td>
<td>Confidence in knowledge and ability related to career development topics.</td>
</tr>
<tr>
<td>Career Readiness</td>
<td>8</td>
<td>.931</td>
<td>.926</td>
<td>Competencies for Career Readiness – National Association Of Colleges and Employers</td>
</tr>
<tr>
<td>Interest in ML Careers/Jobs</td>
<td>10</td>
<td>.853</td>
<td>.909</td>
<td>Interest in ML-related jobs/careers</td>
</tr>
<tr>
<td>ABET SLOs</td>
<td>11</td>
<td>.937</td>
<td>.940</td>
<td>Confidence in the knowledge and ability related to the ABET SLOs</td>
</tr>
<tr>
<td>Engineering Efficacy</td>
<td>6</td>
<td>.881</td>
<td>.937</td>
<td>Undergraduate Students’ Engineering Self Efficacy</td>
</tr>
<tr>
<td>General Knowledge and Ability</td>
<td>5</td>
<td>.830</td>
<td>.893</td>
<td>Persistence in degree and career</td>
</tr>
<tr>
<td>Engineering Skills</td>
<td>5</td>
<td>.939</td>
<td>.943</td>
<td></td>
</tr>
<tr>
<td>Engineering design</td>
<td>8</td>
<td>.935</td>
<td>.944</td>
<td></td>
</tr>
<tr>
<td>Tinkering Skills</td>
<td>14</td>
<td>.875</td>
<td>.893</td>
<td></td>
</tr>
<tr>
<td>Intent to Persist</td>
<td>23</td>
<td>.935</td>
<td>X</td>
<td>Longitudinal Assessment of Engineering Self Efficacy</td>
</tr>
<tr>
<td>21st Century Skills</td>
<td>11</td>
<td>.943</td>
<td>X</td>
<td>Confidence in relation to 21st century skills (e.g. teamwork, communication)</td>
</tr>
<tr>
<td>Culturally Responsive Teaching Self Efficacy</td>
<td>27</td>
<td>X</td>
<td>.983</td>
<td>Students' perceptions of instructors' use of culturally responsive teaching approaches</td>
</tr>
<tr>
<td>Culturally Responsive Teaching Outcome Expectations Scale</td>
<td>20</td>
<td>X</td>
<td>.954</td>
<td>Students perceptions of outcomes expected from culturally responsive teaching</td>
</tr>
</tbody>
</table>
Pre Course Survey Findings

Confidence in Machine Learning Student Learning Outcomes

As might be expected, students were not generally very confident in their knowledge and abilities related to the Applied Machine Learning Course student learning outcomes prior to course instruction. Overall, they indicated the greatest confidence in their ability to investigate, clean and visualize data and least confidence in their ability to apply and tune machine learning models, identify the potential bias in ML models and evaluate the quality of trained regression and classification models.

<table>
<thead>
<tr>
<th>ML Course SLO</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigate, clean and visualize data</td>
<td>2.85 1.289</td>
<td>3.19 1.504</td>
<td>3.24 1.091</td>
<td>2.26 1.010</td>
</tr>
<tr>
<td>Understand and frame a problem as a supervised machine learning problem</td>
<td>2.02 1.162</td>
<td>2.24 1.338</td>
<td>2.13 1.088</td>
<td>1.75 1.032</td>
</tr>
<tr>
<td>including whether it is a regression or classification problem and to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>incorporate the application requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apply and tune common machine learning (ML) models in Python by making use</td>
<td>1.75 1.043</td>
<td>1.86 1.153</td>
<td>1.75 1.125</td>
<td>1.67 .917</td>
</tr>
<tr>
<td>of multiple ML toolkits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrate the ability to qualitatively and quantitatively evaluate the</td>
<td>1.97 1.080</td>
<td>2.14 1.276</td>
<td>2.00 1.155</td>
<td>1.79 .833</td>
</tr>
<tr>
<td>quality of trained regression and classification models</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communicate technical concepts (oral and written) for an audience who may</td>
<td>2.70 1.308</td>
<td>2.81 1.537</td>
<td>2.56 1.315</td>
<td>2.71 1.122</td>
</tr>
<tr>
<td>have limited technical background</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify the potential bias in ML models and explain its implications</td>
<td>1.87 .991</td>
<td>1.95 1.024</td>
<td>1.94 1.124</td>
<td>1.75 .897</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5=A great extent)
Confidence in ABET Student Learning Outcomes

At the beginning of the course, students did express a moderately high level of confidence in the knowledge and ability related to the ABET student learning outcomes as all responses averaged above the scale midpoint of 3 and 8 of the 11 averaging 3.5 or above. Students were especially confident in their ability to communicate effectively (M=4.11), understand their professional and ethical responsibilities (M=3.97), recognize the need and ability to engage in professional development/improvement (M=3.87) and work effectively on multidisciplinary teams (M=3.89).

<table>
<thead>
<tr>
<th>ABET SLO</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply knowledge of mathematics, science and engineering</td>
<td>3.67 1.012</td>
<td>3.90 .889</td>
<td>3.56 1.209</td>
<td>3.54 .977</td>
</tr>
<tr>
<td>Design and conduct experiments and interpret the resulting data</td>
<td>3.48 1.170</td>
<td>3.81 1.078</td>
<td>3.29 1.312</td>
<td>3.33 1.129</td>
</tr>
<tr>
<td>Design a system, component, or process to meet desired needs</td>
<td>3.41 1.160</td>
<td>3.57 1.207</td>
<td>3.50 1.265</td>
<td>3.21 1.062</td>
</tr>
<tr>
<td>Work effectively on a multidisciplinary team</td>
<td>3.92 1.076</td>
<td>4.19 1.123</td>
<td>3.71 1.105</td>
<td>3.83 1.007</td>
</tr>
<tr>
<td>Identify, formulate and solve engineering problems</td>
<td>3.43 1.024</td>
<td>3.52 1.209</td>
<td>3.25 1.183</td>
<td>3.46 .721</td>
</tr>
<tr>
<td>Understand professional and ethical responsibility</td>
<td>4.00 1.033</td>
<td>4.10 1.300</td>
<td>4.00 .894</td>
<td>3.92 .881</td>
</tr>
<tr>
<td>Communicate effectively</td>
<td>4.15 .899</td>
<td>4.15 1.040</td>
<td>3.87 .719</td>
<td>4.33 .868</td>
</tr>
<tr>
<td>Understand the broad impact of engineering solutions in a global, economic, environmental and social context</td>
<td>3.65 1.073</td>
<td>3.76 1.091</td>
<td>3.24 1.147</td>
<td>3.83 .963</td>
</tr>
<tr>
<td>Recognize the need for and ability to engage in professional development/improvement</td>
<td>3.89 .994</td>
<td>4.00 1.095</td>
<td>3.82 1.015</td>
<td>3.83 .917</td>
</tr>
<tr>
<td>Understanding and awareness of contemporary issues</td>
<td>3.66 .974</td>
<td>3.71 1.007</td>
<td>3.71 .920</td>
<td>3.58 1.018</td>
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<tr>
<td>Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.</td>
<td>3.61 1.014</td>
<td>3.81 .981</td>
<td>3.35 1.115</td>
<td>3.62 .970</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5=A great extent)
Confidence in Machine Learning Units and Topics

Students were asked to indicate the extent to which they confident in their knowledge and ability related to each of the units and topics to be addressed in the Applied Machine Learning Course. Consistent with their confidence in the overall student learning outcomes, students were not very confident in their knowledge and abilities related to the specific content in the course prior to course instruction. These will be examined again at the end of the course to determine improvement in their confidence.

### Overall Sample (N=62)

<table>
<thead>
<tr>
<th>Unit/Topic</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>Computer Science</td>
<td>3.05</td>
<td>1.146</td>
<td>3.10</td>
<td>1.294</td>
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<td>.772</td>
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<tr>
<td>Python</td>
<td>2.66</td>
<td>1.187</td>
<td>2.19</td>
<td>1.030</td>
<td>3.12</td>
<td>1.054</td>
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<tr>
<td>Straight Line Equation</td>
<td>3.05</td>
<td>1.465</td>
<td>3.14</td>
<td>1.424</td>
<td>3.38</td>
<td>1.668</td>
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<tr>
<td>Functions</td>
<td>3.68</td>
<td>1.128</td>
<td>4.14</td>
<td>.727</td>
<td>3.71</td>
<td>1.312</td>
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<tr>
<td>Matrix Algebra</td>
<td>2.72</td>
<td>1.213</td>
<td>2.76</td>
<td>1.338</td>
<td>3.35</td>
<td>1.057</td>
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<tr>
<td>Normal Distribution Properties</td>
<td>2.85</td>
<td>1.278</td>
<td>3.10</td>
<td>1.261</td>
<td>2.76</td>
<td>1.300</td>
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<tr>
<td>Hypothesis Testing</td>
<td>3.07</td>
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<td>3.52</td>
<td>1.327</td>
<td>3.12</td>
<td>1.166</td>
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<td>Probability and p-values</td>
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<td>1.282</td>
<td>3.38</td>
<td>1.117</td>
<td>2.69</td>
<td>1.352</td>
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<td>Data Science</td>
<td>2.34</td>
<td>1.031</td>
<td>2.62</td>
<td>1.071</td>
<td>2.24</td>
<td>1.147</td>
</tr>
<tr>
<td>Types of Machine Learning (ML) Models</td>
<td>1.75</td>
<td>.925</td>
<td>1.90</td>
<td>1.221</td>
<td>1.62</td>
<td>.719</td>
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<tr>
<td>Ethical Consequences of Machine Learning</td>
<td>2.12</td>
<td>1.223</td>
<td>2.40</td>
<td>1.392</td>
<td>2.12</td>
<td>1.360</td>
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<tr>
<td>Data Analysis and Manipulation - Colab notebooks</td>
<td>1.92</td>
<td>1.085</td>
<td>1.81</td>
<td>1.078</td>
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<td>1.155</td>
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<tr>
<td>Data Analysis and Manipulation - Panda Series and Panda DataFrames</td>
<td>1.74</td>
<td>1.047</td>
<td>1.76</td>
<td>1.091</td>
<td>1.75</td>
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<tr>
<td>Visualization of data</td>
<td>2.71</td>
<td>1.200</td>
<td>2.89</td>
<td>1.329</td>
<td>3.00</td>
<td>1.461</td>
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<tr>
<td>Acquiring and downloading data</td>
<td>2.85</td>
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<td>2.95</td>
<td>1.322</td>
<td>3.00</td>
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<td>Exploratory data analysis</td>
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<td>1.101</td>
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<td>1.155</td>
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<tr>
<td>Regression analysis</td>
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<td>1.223</td>
<td>2.43</td>
<td>1.326</td>
<td>2.37</td>
<td>1.360</td>
</tr>
<tr>
<td>Using scikit-learn for regression analysis</td>
<td>1.65</td>
<td>.971</td>
<td>1.65</td>
<td>1.137</td>
<td>1.69</td>
<td>.946</td>
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<tr>
<td>Using TensorFlow</td>
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<td>.828</td>
<td>1.57</td>
<td>1.076</td>
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<td>.619</td>
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<tr>
<td>Binary Classification methods</td>
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<td>1.087</td>
<td>2.00</td>
<td>1.338</td>
<td>1.69</td>
<td>.946</td>
</tr>
<tr>
<td>Multiclass Classification</td>
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<td>1.395</td>
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<tr>
<td>Image - Video Classification</td>
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<td>1.89</td>
<td>1.286</td>
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<td>.892</td>
</tr>
</tbody>
</table>

(Continued on Page 10)
### Confidence in Machine Learning Units and Topics

(Continued from Page 9)

<table>
<thead>
<tr>
<th>Machine Learning Unit and Topic</th>
<th>Scale 1</th>
<th>Scale 2</th>
<th>Scale 3</th>
<th>Scale 4</th>
<th>Scale 5</th>
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</thead>
<tbody>
<tr>
<td><strong>Deep Learning</strong></td>
<td>1.83</td>
<td>1.122</td>
<td>2.10</td>
<td>1.252</td>
<td>1.50</td>
</tr>
<tr>
<td><strong>Recurrent Neural Network</strong></td>
<td>1.56</td>
<td>.958</td>
<td>1.86</td>
<td>1.276</td>
<td>1.31</td>
</tr>
<tr>
<td><strong>Natural Language Processing</strong></td>
<td>1.77</td>
<td>1.079</td>
<td>1.85</td>
<td>1.268</td>
<td>1.69</td>
</tr>
<tr>
<td><strong>Transfer Learning</strong></td>
<td>1.53</td>
<td>.929</td>
<td>1.75</td>
<td>1.118</td>
<td>1.44</td>
</tr>
<tr>
<td><strong>Clustering</strong></td>
<td>1.80</td>
<td>1.108</td>
<td>1.95</td>
<td>1.203</td>
<td>1.88</td>
</tr>
<tr>
<td><strong>k-Means models</strong></td>
<td>1.68</td>
<td>.983</td>
<td>1.80</td>
<td>1.105</td>
<td>1.81</td>
</tr>
<tr>
<td><strong>Embedding</strong></td>
<td>1.81</td>
<td>1.131</td>
<td>1.90</td>
<td>1.136</td>
<td>1.81</td>
</tr>
<tr>
<td><strong>Decision Trees and Random Forest</strong></td>
<td>1.78</td>
<td>1.075</td>
<td>2.05</td>
<td>1.359</td>
<td>1.88</td>
</tr>
<tr>
<td><strong>Bayesian Modeling</strong></td>
<td>1.57</td>
<td>1.047</td>
<td>1.95</td>
<td>1.465</td>
<td>1.44</td>
</tr>
<tr>
<td><strong>Support Vector Machines (SVM)</strong></td>
<td>1.41</td>
<td>.824</td>
<td>1.57</td>
<td>1.076</td>
<td>1.31</td>
</tr>
<tr>
<td><strong>XG Boost</strong></td>
<td>1.32</td>
<td>.748</td>
<td>1.55</td>
<td>1.099</td>
<td>1.13</td>
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<tr>
<td><strong>Activation Functions</strong></td>
<td>1.52</td>
<td>.942</td>
<td>1.67</td>
<td>1.017</td>
<td>1.56</td>
</tr>
<tr>
<td><strong>Big O</strong></td>
<td>2.13</td>
<td>1.346</td>
<td>2.24</td>
<td>1.546</td>
<td>2.53</td>
</tr>
<tr>
<td><strong>Dimensionality Reduction</strong></td>
<td>1.48</td>
<td>.887</td>
<td>1.67</td>
<td>1.111</td>
<td>1.50</td>
</tr>
<tr>
<td><strong>Loss Functions</strong></td>
<td>1.58</td>
<td>1.021</td>
<td>1.70</td>
<td>1.218</td>
<td>1.60</td>
</tr>
<tr>
<td><strong>Probability and Statistics</strong></td>
<td>3.00</td>
<td>1.329</td>
<td>3.38</td>
<td>1.396</td>
<td>3.06</td>
</tr>
<tr>
<td><strong>Regular Expressions</strong></td>
<td>2.77</td>
<td>1.270</td>
<td>3.00</td>
<td>1.483</td>
<td>2.69</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5=A great extent)
Engineering Self-Efficacy

In general, students indicated moderately high levels of confidence related to engineering with all items averaging above the scale midpoint of 3. At the beginning of this course, students were especially confident in relation to general efficacy and skills efficacy.

<table>
<thead>
<tr>
<th></th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Self-Efficacy</td>
<td>Mean: 4.19, SD: .61</td>
<td>Mean: 4.31, SD: .54</td>
<td>Mean: 4.22, SD: .56</td>
<td>Mean: 4.07, SD: .71</td>
</tr>
<tr>
<td>I can master the content in my major courses</td>
<td>Mean: 4.25, SD: .722</td>
<td>Mean: 4.33, SD: .577</td>
<td>Mean: 4.56, SD: .629</td>
<td>Mean: 3.96, SD: .806</td>
</tr>
<tr>
<td>I can master the content in even the most challenging engineering course</td>
<td>Mean: 3.77, SD: .895</td>
<td>Mean: 4.00, SD: .775</td>
<td>Mean: 3.94, SD: .827</td>
<td>Mean: 3.46, SD: .977</td>
</tr>
<tr>
<td>I can do good work in my major coursework</td>
<td>Mean: 4.35, SD: .812</td>
<td>Mean: 4.52, SD: .680</td>
<td>Mean: 4.41, SD: .618</td>
<td>Mean: 4.17, SD: 1.007</td>
</tr>
<tr>
<td>I can do an excellent job on engineering-related problems or tasks I am assigned</td>
<td>Mean: 4.18, SD: .736</td>
<td>Mean: 4.33, SD: .577</td>
<td>Mean: 3.94, SD: .748</td>
<td>Mean: 4.21, SD: .833</td>
</tr>
<tr>
<td>I can learn the content taught in my engineering-related courses</td>
<td>Mean: 4.37, SD: .683</td>
<td>Mean: 4.38, SD: .740</td>
<td>Mean: 4.35, SD: .606</td>
<td>Mean: 4.37, SD: .711</td>
</tr>
<tr>
<td>I can earn good grades in my engineering-related courses</td>
<td>Mean: 4.27, SD: .772</td>
<td>Mean: 4.33, SD: .658</td>
<td>Mean: 4.24, SD: .752</td>
<td>Mean: 4.25, SD: .897</td>
</tr>
<tr>
<td>Engineering Skills Self-Efficacy</td>
<td>Mean: 4.14, SD: .61</td>
<td>Mean: 4.23, SD: .61</td>
<td>Mean: 4.10, SD: .72</td>
<td>Mean: 4.09, SD: .72</td>
</tr>
<tr>
<td>I can perform experiments independently</td>
<td>Mean: 3.84, SD: .978</td>
<td>Mean: 4.19, SD: .873</td>
<td>Mean: 3.59, SD: 1.004</td>
<td>Mean: 3.71, SD: 1.999</td>
</tr>
<tr>
<td>I can analyze data from experiments</td>
<td>Mean: 4.15, SD: .807</td>
<td>Mean: 4.29, SD: .644</td>
<td>Mean: 4.18, SD: .728</td>
<td>Mean: 4.00, SD: 1.078</td>
</tr>
<tr>
<td>I can orally communicate results from experiments</td>
<td>Mean: 4.18, SD: .820</td>
<td>Mean: 4.24, SD: .700</td>
<td>Mean: 4.00, SD: .866</td>
<td>Mean: 4.25, SD: .897</td>
</tr>
<tr>
<td>I can communicate results in written form</td>
<td>Mean: 4.26, SD: .788</td>
<td>Mean: 4.10, SD: .831</td>
<td>Mean: 4.35, SD: .702</td>
<td>Mean: 4.33, SD: .816</td>
</tr>
<tr>
<td>I can solve problems using a computer</td>
<td>Mean: 4.29, SD: .797</td>
<td>Mean: 4.33, SD: .796</td>
<td>Mean: 4.41, SD: .618</td>
<td>Mean: 4.17, SD: 1.17</td>
</tr>
<tr>
<td>Design Self-Efficacy</td>
<td>Mean: 3.89, SD: .76</td>
<td>Mean: 4.01, SD: .65</td>
<td>Mean: 3.86, SD: .75</td>
<td>Mean: 3.81, SD: .86</td>
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<tr>
<td>I can design new things</td>
<td>Mean: 4.00, SD: .887</td>
<td>Mean: 4.19, SD: .790</td>
<td>Mean: 3.82, SD: .951</td>
<td>Mean: 3.96, SD: .955</td>
</tr>
<tr>
<td>I can identify a design need</td>
<td>Mean: 3.82, SD: .840</td>
<td>Mean: 3.90, SD: .768</td>
<td>Mean: 3.88, SD: .857</td>
<td>Mean: 3.71, SD: .908</td>
</tr>
<tr>
<td>I can develop design solutions</td>
<td>Mean: 3.94, SD: .807</td>
<td>Mean: 4.10, SD: .700</td>
<td>Mean: 3.88, SD: .857</td>
<td>Mean: 3.83, SD: .868</td>
</tr>
<tr>
<td>I can evaluate a design</td>
<td>Mean: 3.89, SD: .851</td>
<td>Mean: 4.05, SD: .669</td>
<td>Mean: 3.82, SD: .951</td>
<td>Mean: 3.79, SD: .932</td>
</tr>
</tbody>
</table>

(Continued on Page 12)
### Engineering Self-Efficacy

(Continued from Page 11)

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I can reorganize changes needed for a design solution to work</strong></td>
<td>3.81</td>
<td>.884</td>
<td>3.86</td>
<td>.854</td>
<td>3.82</td>
<td>.728</td>
<td>3.75</td>
</tr>
<tr>
<td><strong>Tinkering Self-Efficacy</strong></td>
<td>3.81</td>
<td>.89</td>
<td>3.97</td>
<td>.69</td>
<td>3.44</td>
<td>.98</td>
<td>3.93</td>
</tr>
<tr>
<td><strong>I can work with tools and use them to build things</strong></td>
<td>3.90</td>
<td>1.003</td>
<td>4.10</td>
<td>.889</td>
<td>3.41</td>
<td>1.004</td>
<td>4.08</td>
</tr>
<tr>
<td><strong>I can work with tools and use them to fix things</strong></td>
<td>3.95</td>
<td>.931</td>
<td>4.14</td>
<td>.854</td>
<td>3.53</td>
<td>1.007</td>
<td>4.08</td>
</tr>
<tr>
<td><strong>I can work with machines</strong></td>
<td>3.90</td>
<td>1.127</td>
<td>4.29</td>
<td>.956</td>
<td>3.41</td>
<td>1.176</td>
<td>3.92</td>
</tr>
<tr>
<td><strong>I can fix machines</strong></td>
<td>3.24</td>
<td>1.155</td>
<td>3.38</td>
<td>.973</td>
<td>3.00</td>
<td>1.369</td>
<td>3.29</td>
</tr>
<tr>
<td><strong>I can manipulate components and devices</strong></td>
<td>3.67</td>
<td>.961</td>
<td>3.80</td>
<td>.834</td>
<td>3.35</td>
<td>1.115</td>
<td>3.79</td>
</tr>
<tr>
<td><strong>I can assemble things</strong></td>
<td>4.00</td>
<td>.992</td>
<td>4.05</td>
<td>.669</td>
<td>3.65</td>
<td>1.169</td>
<td>4.21</td>
</tr>
<tr>
<td><strong>I can disassemble things</strong></td>
<td>3.97</td>
<td>1.086</td>
<td>4.10</td>
<td>.831</td>
<td>3.53</td>
<td>1.328</td>
<td>4.17</td>
</tr>
<tr>
<td><strong>I can apply technical concepts in engineering</strong></td>
<td>3.87</td>
<td>1.032</td>
<td>4.05</td>
<td>.805</td>
<td>3.41</td>
<td>1.278</td>
<td>4.04</td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
Longitudinal Assessment of Engineering Self-Efficacy

Students expressed high levels of efficacy in response to the LAESE items with responses averaging above 3.5 and all but 6 above 4.0. Students most strongly agreed that they able to make friends with people with different backgrounds (M=4.65) and values and they would complete their degree at their current institution (M=4.61).

<table>
<thead>
<tr>
<th>LAESE Items</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can relate to people around me in my classes</td>
<td>3.98</td>
<td>3.71</td>
<td>3.88</td>
<td>4.29</td>
</tr>
<tr>
<td></td>
<td>.975</td>
<td>1.007</td>
<td>1.088</td>
<td>.806</td>
</tr>
<tr>
<td>I can succeed in an engineering degree program</td>
<td>4.48</td>
<td>4.57</td>
<td>4.41</td>
<td>4.46</td>
</tr>
<tr>
<td></td>
<td>.646</td>
<td>.598</td>
<td>.712</td>
<td>.658</td>
</tr>
<tr>
<td>I have a lot in common with other students in my classes</td>
<td>3.84</td>
<td>3.67</td>
<td>3.76</td>
<td>4.04</td>
</tr>
<tr>
<td></td>
<td>.853</td>
<td>.856</td>
<td>.970</td>
<td>.751</td>
</tr>
<tr>
<td>Someone like me can succeed in an engineering career</td>
<td>4.43</td>
<td>4.57</td>
<td>4.19</td>
<td>4.48</td>
</tr>
<tr>
<td></td>
<td>.767</td>
<td>.598</td>
<td>1.109</td>
<td>.593</td>
</tr>
<tr>
<td>The other students in my classes share my personal interests</td>
<td>3.80</td>
<td>3.76</td>
<td>3.62</td>
<td>3.96</td>
</tr>
<tr>
<td></td>
<td>.853</td>
<td>.995</td>
<td>.885</td>
<td>.690</td>
</tr>
<tr>
<td>I can succeed in an engineering program while NOT having to give up</td>
<td>3.74</td>
<td>3.86</td>
<td>3.71</td>
<td>3.67</td>
</tr>
<tr>
<td>participation in my outside interests (e.g. family, friends, extracurricular activities)</td>
<td>1.085</td>
<td>.964</td>
<td>1.105</td>
<td>1.204</td>
</tr>
<tr>
<td>I can relate to people around me in my extracurricular activities</td>
<td>4.06</td>
<td>4.00</td>
<td>3.76</td>
<td>4.33</td>
</tr>
<tr>
<td></td>
<td>.827</td>
<td>.707</td>
<td>1.147</td>
<td>.565</td>
</tr>
<tr>
<td>I can complete the math requirements for my degree program,</td>
<td>4.45</td>
<td>4.43</td>
<td>4.35</td>
<td>4.54</td>
</tr>
<tr>
<td></td>
<td>.761</td>
<td>.676</td>
<td>1.057</td>
<td>.588</td>
</tr>
<tr>
<td>Doing well in math will enhance my career/job opportunities</td>
<td>4.29</td>
<td>4.19</td>
<td>4.35</td>
<td>4.33</td>
</tr>
<tr>
<td></td>
<td>.982</td>
<td>.750</td>
<td>1.057</td>
<td>1.129</td>
</tr>
<tr>
<td>A degree in engineering will allow me to obtain a well paying job</td>
<td>4.52</td>
<td>4.52</td>
<td>4.29</td>
<td>4.67</td>
</tr>
<tr>
<td></td>
<td>.805</td>
<td>.680</td>
<td>1.105</td>
<td>.637</td>
</tr>
<tr>
<td>I will do well in my major courses this year</td>
<td>4.58</td>
<td>4.48</td>
<td>4.59</td>
<td>4.67</td>
</tr>
<tr>
<td></td>
<td>.615</td>
<td>.680</td>
<td>.618</td>
<td>.565</td>
</tr>
</tbody>
</table>

(Continued on Page 14)
### Longitudinal Assessment of Engineering Self-Efficacy

(Continued from Page 13)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I will complete my degree at my current institution</td>
<td>4.61</td>
<td>.686</td>
<td>4.52</td>
<td>.680</td>
<td>4.53</td>
<td>.874</td>
<td>4.75</td>
<td>.532</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A degree in engineering will give me the kind of lifestyle I want</td>
<td>4.47</td>
<td>.804</td>
<td>4.43</td>
<td>.676</td>
<td>4.24</td>
<td>1.091</td>
<td>4.67</td>
<td>.637</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can make friends with people from different backgrounds and/or values</td>
<td>4.65</td>
<td>.575</td>
<td>4.57</td>
<td>.598</td>
<td>4.59</td>
<td>.618</td>
<td>4.75</td>
<td>.532</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doing well in my classes will increase my sense of self-worth</td>
<td>4.31</td>
<td>.822</td>
<td>4.24</td>
<td>.768</td>
<td>4.12</td>
<td>.857</td>
<td>4.50</td>
<td>.834</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I will feel &quot;part of the group&quot; on my job if I enter engineering</td>
<td>3.84</td>
<td>1.027</td>
<td>3.81</td>
<td>.873</td>
<td>3.47</td>
<td>1.125</td>
<td>4.13</td>
<td>1.035</td>
<td></td>
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</tr>
<tr>
<td>I can complete the science (e.g. physics, chemistry) requirements for my degree</td>
<td>4.52</td>
<td>.741</td>
<td>4.52</td>
<td>.680</td>
<td>4.41</td>
<td>.939</td>
<td>4.58</td>
<td>.654</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taking advance math courses will help keep my career options option</td>
<td>3.95</td>
<td>1.137</td>
<td>3.95</td>
<td>1.024</td>
<td>3.88</td>
<td>1.166</td>
<td>4.00</td>
<td>1.251</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A degree in engineering will allow me to get a job where I can use my talents and creativity</td>
<td>4.21</td>
<td>.926</td>
<td>4.14</td>
<td>.910</td>
<td>4.00</td>
<td>1.118</td>
<td>4.42</td>
<td>.776</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can persist in engineering this academic year.</td>
<td>4.46</td>
<td>.673</td>
<td>4.33</td>
<td>.730</td>
<td>4.47</td>
<td>.624</td>
<td>4.57</td>
<td>.662</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can approach a faculty or staff member to get assistance when needed.</td>
<td>4.13</td>
<td>.806</td>
<td>4.05</td>
<td>.759</td>
<td>4.12</td>
<td>.928</td>
<td>4.21</td>
<td>.779</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can adjust to new work or learning environments</td>
<td>4.47</td>
<td>.620</td>
<td>4.48</td>
<td>.602</td>
<td>4.47</td>
<td>.624</td>
<td>4.46</td>
<td>.658</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A degree in engineering will allow me to get a job I like</td>
<td>4.41</td>
<td>.804</td>
<td>4.48</td>
<td>.602</td>
<td>4.06</td>
<td>1.088</td>
<td>4.61</td>
<td>.656</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
Confidence in 21st Century Skills

Students expressed high levels of confidence in their ability in their 21st century skills, especially regarding their respect for the differences of their peers (M=4.65), their confidence in working with students from different backgrounds (M=4.58), include others’ perspectives when making decisions (M=4.50).

<table>
<thead>
<tr>
<th>Efficacy - 21st Century Skills</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am confident I can lead others to accomplish a goal.</td>
<td>4.18 .820</td>
<td>4.14 .793</td>
<td>4.00 1.00 0</td>
<td>4.33 .702</td>
</tr>
<tr>
<td>I am confident I can encourage others to do their best.</td>
<td>4.31 .841</td>
<td>4.19 .928</td>
<td>4.18 1.01 5</td>
<td>4.50 .590</td>
</tr>
<tr>
<td>I am confident I can produce high quality work.</td>
<td>4.50 .647</td>
<td>4.43 .676</td>
<td>4.53 .717</td>
<td>4.54 .588</td>
</tr>
<tr>
<td>I am confident I can respect the differences of my peers.</td>
<td>4.65 .575</td>
<td>4.48 .680</td>
<td>4.59 .507</td>
<td>4.83 .482</td>
</tr>
<tr>
<td>I am confident I can help my peers.</td>
<td>4.24 .824</td>
<td>4.10 .768</td>
<td>4.29 .849</td>
<td>4.33 .868</td>
</tr>
<tr>
<td>I am confident I can include others’ perspectives when making decisions.</td>
<td>4.50 .741</td>
<td>4.38 .921</td>
<td>4.53 .624</td>
<td>4.58 .654</td>
</tr>
<tr>
<td>I am confident I can make changes when things do not go as planned.</td>
<td>4.44 .692</td>
<td>4.33 .796</td>
<td>4.35 .702</td>
<td>4.58 .584</td>
</tr>
<tr>
<td>I am confident I can set my own learning goals.</td>
<td>4.29 .857</td>
<td>4.10 .889</td>
<td>4.24 .903</td>
<td>4.50 .780</td>
</tr>
<tr>
<td>I am confident I can manage my time wisely when working on my own.</td>
<td>4.15 .938</td>
<td>4.10 .889</td>
<td>4.24 .831</td>
<td>4.13 1.076</td>
</tr>
<tr>
<td>When I have many assignments, I can choose which ones need to be done first.</td>
<td>4.40 .799</td>
<td>4.38 .921</td>
<td>4.41 .712</td>
<td>4.42 .776</td>
</tr>
<tr>
<td>I am confident I can work well with students from different backgrounds.</td>
<td>4.58 .691</td>
<td>4.38 .805</td>
<td>4.53 .717</td>
<td>4.79 .509</td>
</tr>
</tbody>
</table>
Persistence

Students generally indicated a strong intention to persist. More specifically, they indicated that they planned to take courses in their major next year (M=4.52), complete their current degree (M=4.55), continue their education in their current field (M=4.57) and see themselves working in the field for at least 5 years (M=4.52).

<table>
<thead>
<tr>
<th>Intention to Persist</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Next year, I plan to take courses in my major discipline</td>
<td>Mean: 4.52, SD: .770</td>
<td>Mean: 4.38, SD: .805</td>
<td>Mean: 4.47, SD: .800</td>
<td>Mean: 4.68, SD: .716</td>
</tr>
<tr>
<td>I intend to get my degree in my current major</td>
<td>Mean: 4.55, SD: .746</td>
<td>Mean: 4.48, SD: .750</td>
<td>Mean: 4.53, SD: .717</td>
<td>Mean: 4.64, SD: .790</td>
</tr>
<tr>
<td>I am sure that I will continue my education in my major field</td>
<td>Mean: 4.57, SD: .698</td>
<td>Mean: 4.48, SD: .750</td>
<td>Mean: 4.35, SD: .702</td>
<td>Mean: 4.82, SD: .588</td>
</tr>
<tr>
<td>I intend to get an advanced degree in my major field</td>
<td>Mean: 4.05, SD: .910</td>
<td>Mean: 4.05, SD: .805</td>
<td>Mean: 3.76, SD: 1.033</td>
<td>Mean: 4.27, SD: .883</td>
</tr>
<tr>
<td>I plan to pursue and secure an internship this year.</td>
<td>Mean: 4.33, SD: .851</td>
<td>Mean: 4.29, SD: .784</td>
<td>Mean: 4.18, SD: 951</td>
<td>Mean: 4.48, SD: .846</td>
</tr>
<tr>
<td>I intend to get a job in my major field</td>
<td>Mean: 4.44, SD: .827</td>
<td>Mean: 4.48, SD: .750</td>
<td>Mean: 4.12, SD: 993</td>
<td>Mean: 4.65, SD: .714</td>
</tr>
<tr>
<td>I can see myself working in my current field for at least 5 years.</td>
<td>Mean: 4.52, SD: .725</td>
<td>Mean: 4.33, SD: .796</td>
<td>Mean: 4.47, SD: .717</td>
<td>Mean: 4.73, SD: .631</td>
</tr>
<tr>
<td>I plan to devote my career to my current major discipline</td>
<td>Mean: 4.44, SD: .764</td>
<td>Mean: 4.33, SD: .796</td>
<td>Mean: 4.29, SD: 849</td>
<td>Mean: 4.65, SD: .647</td>
</tr>
<tr>
<td>I plan to take additional courses related to machine learning.</td>
<td>Mean: 3.92, SD: 1.053</td>
<td>Mean: 3.86, SD: .964</td>
<td>Mean: 4.06, SD: 1.197</td>
<td>Mean: 3.87, SD: 1.058</td>
</tr>
<tr>
<td>I intend to seek internship opportunities related to machine learning</td>
<td>Mean: 3.90, SD: 1.044</td>
<td>Mean: 4.00, SD: .894</td>
<td>Mean: 3.88, SD: 1.111</td>
<td>Mean: 3.83, SD: 1.154</td>
</tr>
<tr>
<td>I am considering changing my major to something more directly related to machine learning</td>
<td>Mean: 2.92, SD: 1.094</td>
<td>Mean: 3.30, SD: 1.081</td>
<td>Mean: 2.76, SD: 1.091</td>
<td>Mean: 2.70, SD: 1.063</td>
</tr>
<tr>
<td>I plan to pursue an advanced degree related to machine learning</td>
<td>Mean: 3.23, SD: 1.146</td>
<td>Mean: 3.48, SD: 1.078</td>
<td>Mean: 3.59, SD: 1.064</td>
<td>Mean: 2.74, SD: 1.137</td>
</tr>
<tr>
<td>I plan to get a job related to machine learning.</td>
<td>Mean: 3.52, SD: 1.074</td>
<td>Mean: 3.48, SD: 1.167</td>
<td>Mean: 3.82, SD: 1.074</td>
<td>Mean: 3.35, SD: .982</td>
</tr>
<tr>
<td>I would like to have a career related to machine learning</td>
<td>Mean: 3.54, SD: .993</td>
<td>Mean: 3.71, SD: .956</td>
<td>Mean: 3.71, SD: 1.047</td>
<td>Mean: 3.26, SD: .964</td>
</tr>
</tbody>
</table>

1—Not TRUE of me, 5—VERY TRUE of me
Confidence in Career Development and Preparation

In general, students expressed confidence in their abilities as they prepare for a career with all but one item averaging above the scale midpoint. They indicated the greatest confidence in their abilities related to their cultural awareness (M=4.33), teamwork skills (M=4.27), having high ethical standards (M=4.25). Areas in which there is room for improvement included security knowledge (M=3.31) and knowledge of physical science and engineering fundamentals (M=3.53).
Career development is a unit with this course and students will be engaged in activities aimed to better prepare them with the skills they need to get a job and begin their career. In response to these items, students indicated a high level of confidence with all items averaging above 3.5 (using a 5-point scale). Students expressed the most confidence in their ability to receive and use feedback from others (M=4.26), talk with faculty and others about potential internship or job opportunities (M=4.03), and apply for internship or job opportunities (M=4.07).

<table>
<thead>
<tr>
<th>Constructing a resume</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Constructing a resume</td>
<td>3.85</td>
<td>.910</td>
<td>3.95</td>
<td>.826</td>
</tr>
<tr>
<td>Meeting and engaging with professionals in your field</td>
<td>3.92</td>
<td>1.021</td>
<td>4.15</td>
<td>.813</td>
</tr>
<tr>
<td>Giving feedback to others</td>
<td>3.88</td>
<td>.885</td>
<td>4.05</td>
<td>.705</td>
</tr>
<tr>
<td>Receiving and using feedback from others</td>
<td>4.26</td>
<td>.814</td>
<td>4.20</td>
<td>.768</td>
</tr>
<tr>
<td>Working with recruiters or career services related to potential jobs</td>
<td>3.93</td>
<td>.910</td>
<td>4.05</td>
<td>.826</td>
</tr>
<tr>
<td>Talking with faculty and others about potential internship of job opportunities</td>
<td>4.03</td>
<td>.920</td>
<td>4.05</td>
<td>.826</td>
</tr>
<tr>
<td>Preparing application materials for an internship or job</td>
<td>3.98</td>
<td>.846</td>
<td>4.10</td>
<td>.718</td>
</tr>
<tr>
<td>Preparing for a job interview</td>
<td>3.74</td>
<td>.911</td>
<td>3.85</td>
<td>.745</td>
</tr>
<tr>
<td>Interviewing for an internship or job</td>
<td>3.69</td>
<td>1.088</td>
<td>3.95</td>
<td>.887</td>
</tr>
<tr>
<td>Preparing for a presentation you will do</td>
<td>3.95</td>
<td>.865</td>
<td>4.05</td>
<td>.686</td>
</tr>
<tr>
<td>Delivering a strong oral presentation with confidence</td>
<td>3.80</td>
<td>1.030</td>
<td>3.95</td>
<td>.759</td>
</tr>
<tr>
<td>Learning about sources for potential internships or jobs</td>
<td>3.88</td>
<td>.885</td>
<td>4.10</td>
<td>.718</td>
</tr>
<tr>
<td>Applying for an internship or job opportunity</td>
<td>4.07</td>
<td>.946</td>
<td>4.10</td>
<td>.788</td>
</tr>
</tbody>
</table>

1 = Not at all, 5 = A great extent
Students were asked to indicate their confidence in relation to the eight competencies of career readiness in the table below. Overall, students expressed confidence in their abilities, especially in terms of teamwork (M=4.30), equity and inclusion (M=4.30) and professionalism (M=4.26).

<table>
<thead>
<tr>
<th>Career Readiness Competencies</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career and Self-Development</td>
<td>3.90 (.936)</td>
<td>3.95 (.805)</td>
<td>3.65 (1.115)</td>
<td>4.04 (.908)</td>
</tr>
<tr>
<td>Communication</td>
<td>3.92 (.893)</td>
<td>4.14 (.793)</td>
<td>3.65 (1.115)</td>
<td>3.92 (.776)</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>4.03 (.809)</td>
<td>4.19 (.750)</td>
<td>3.76 (.970)</td>
<td>4.08 (.717)</td>
</tr>
<tr>
<td>Equity and Inclusion</td>
<td>4.30 (.782)</td>
<td>4.35 (.813)</td>
<td>4.00 (1.866)</td>
<td>4.46 (.658)</td>
</tr>
<tr>
<td>Leadership</td>
<td>3.95 (.884)</td>
<td>4.05 (.865)</td>
<td>3.47 (.943)</td>
<td>4.22 (.736)</td>
</tr>
<tr>
<td>Professionalism</td>
<td>4.26 (.788)</td>
<td>4.19 (.750)</td>
<td>4.06 (.899)</td>
<td>4.46 (.721)</td>
</tr>
<tr>
<td>Teamwork</td>
<td>4.30 (.803)</td>
<td>4.19 (.750)</td>
<td>4.00 (.935)</td>
<td>4.61 (.656)</td>
</tr>
<tr>
<td>Technology</td>
<td>4.18 (.806)</td>
<td>4.14 (.793)</td>
<td>4.12 (.928)</td>
<td>4.26 (.752)</td>
</tr>
</tbody>
</table>

1-Not at all, 5=A great extent
Finally, students were asked to indicate their interest in specific careers related to machine learning. Of the 10 careers listed below, students expressed the greatest interest in software engineering (M=3.71), software development (M=3.64), software programming (M=3.64) and machine learning engineering (M=3.62).

<table>
<thead>
<tr>
<th>Career Interests</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=21)</th>
<th>Kentucky (n=17)</th>
<th>Morgan State (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Engineer</td>
<td>3.71</td>
<td>4.00</td>
<td>3.76</td>
<td>3.42</td>
</tr>
<tr>
<td>Software Programmer</td>
<td>3.64</td>
<td>4.05</td>
<td>3.65</td>
<td>3.29</td>
</tr>
<tr>
<td>Software Developer</td>
<td>3.64</td>
<td>3.95</td>
<td>3.75</td>
<td>3.29</td>
</tr>
<tr>
<td>Data Scientist</td>
<td>3.15</td>
<td>3.48</td>
<td>3.41</td>
<td>2.67</td>
</tr>
<tr>
<td>Computer Engineer</td>
<td>3.39</td>
<td>3.48</td>
<td>3.41</td>
<td>3.29</td>
</tr>
<tr>
<td>Artificial Intelligence Research Scientist</td>
<td>3.42</td>
<td>3.62</td>
<td>4.00</td>
<td>2.83</td>
</tr>
<tr>
<td>Cloud Engineer</td>
<td>3.40</td>
<td>3.76</td>
<td>3.41</td>
<td>3.05</td>
</tr>
<tr>
<td>Machine Learning Scientist</td>
<td>3.45</td>
<td>3.81</td>
<td>3.35</td>
<td>3.21</td>
</tr>
<tr>
<td>Machine Learning Engineer</td>
<td>3.62</td>
<td>4.10</td>
<td>3.41</td>
<td>3.38</td>
</tr>
<tr>
<td>Big Data Engineer</td>
<td>3.15</td>
<td>3.52</td>
<td>2.94</td>
<td>2.96</td>
</tr>
</tbody>
</table>

1=Not at all interested, 5=Very interested
Please Describe the Career in Which you Intend to Pursue.

A total of 52 participants described their career plans. These responses are sorted into the primary categories summarized in the table below. These responses represented various fields with the most frequent being software engineering (15.4%), software development (13.5%), data science (13.5%), electrical engineering (11.5%) or other engineering specializations (13.5%).

<table>
<thead>
<tr>
<th>Career Category</th>
<th>N (%)</th>
<th>Sample responses</th>
</tr>
</thead>
</table>
| Software Engineering            | 8 (15.4%) | - software engineer  
-intend to pursue software engineering  
-undecided, leaning towards software engineer  
-I intend to pursue a job in computer science, preferably software engineering. |
| Software Development            | 7 (13.5%) | - Software Development  
-I intend to be a software developer after working in IT for a few years and getting my certifications to put me on the path.  
-the creation of machine learning software |
| Data Science/AI                  | 7 (13.5%) | -Data Scientist  
-I wish to pursue Artificial Intelligence, with a specific lean toward machine learning.  
-Develop efficient programs and data science solutions to help companies |
| Electrical Engineering           | 6 (11.5%) | -Electrical Engineer  
-I intend to have an electrical engineering career at any corporation that hires me.  
-Any form of industry-based job related to electrical or computer engineering |
| Computer Programming/Engineering | 4 (7.7%)  | - A career that deals with some form of coding or programming. Also, a career with a hands on aspect like constructing circuits or devices.  
-I wish to become an computer engineer and work in the field of smart housing and the IoT |
| Robotics                         | 3 (5.8%)  | -the field of manufacturing and robotic engineering.  
-Autonomous robotics |
| Cybersecurity                    | 3 (5.8%)  | - Cyber security |
| Other Engineering fields         | 7 (13.5%) | Architectural engineering, Applied Engineering, civil engineering, Chemical Engineer |
| Other careers                    | 3 (5.8%)  | -I intend to work in a construction management position.  
-I am very interested into Fintech  
-FBI, CIA, or another government entity. |
| Undecided                        | 4 (7.7%)  | |
**Post Course Results**

**What did students gain from the course?**
Students identified many ways in which the course benefitted them. In the overall sample, over 90% indicated that they learned applications of machine learning (95%), gained valuable knowledge related to machine learning (94%), and networked with other students in their discipline (92%). In addition, over 80% of students indicated gaining experience that would be useful for an internship or job.

<table>
<thead>
<tr>
<th></th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>I learned about the applications of machine learning</td>
<td>95</td>
<td>100</td>
<td>95</td>
<td>91</td>
</tr>
<tr>
<td>I gained valuable knowledge related to machine learning</td>
<td>94</td>
<td>95</td>
<td>100</td>
<td>87</td>
</tr>
<tr>
<td>I networked with other students in my discipline</td>
<td>92</td>
<td>85</td>
<td>95</td>
<td>96</td>
</tr>
<tr>
<td>I gained experience that will be helpful in getting me an internship</td>
<td>84</td>
<td>85</td>
<td>84</td>
<td>83</td>
</tr>
<tr>
<td>I gained experience that will be helpful in getting a job</td>
<td>82</td>
<td>80</td>
<td>84</td>
<td>83</td>
</tr>
<tr>
<td>I established valuable contacts and relationships with faculty in my discipline</td>
<td>79</td>
<td>65</td>
<td>89</td>
<td>83</td>
</tr>
<tr>
<td>I learned something useful for my other classes</td>
<td>77</td>
<td>90</td>
<td>63</td>
<td>78</td>
</tr>
<tr>
<td>This experience will be helpful if/when applying to graduate degree programs</td>
<td>73</td>
<td>55</td>
<td>84</td>
<td>78</td>
</tr>
<tr>
<td>I became more interested in a career related to machine learning</td>
<td>69</td>
<td>75</td>
<td>74</td>
<td>61</td>
</tr>
<tr>
<td>The course helped me figure out what I want to do in the future</td>
<td>66</td>
<td>60</td>
<td>74</td>
<td>65</td>
</tr>
<tr>
<td>Other (briefly explain)</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>
  - Grateful to have gained valuable skills that I can build on
  - Learned the importance of technical presentations
Post Course Feedback

Student post-course feedback was very positive with an average response of 4.15 and 10 of the 12 items below averaging 4 or above for the overall sample. While getting a stipend was important (M=4.44), students also strongly agreed that they established strong relationships with faculty and will keep in touch (M=4.31), planned to keep in touch with students they met (M=4.34) and are better prepared for the coming year after completing this course (M=4.34).
Retrospective Pre-Post Perceptions

Students were asked to indicate their knowledge and abilities in comparison to the beginning of the course using a 5-point scale (1=much worse, 3= about the same, 5=much better). Students’ retrospective pre-post feedback was very positive with an overall average of 4.08 and all items averaging above 3.8 with 9 of the 15 above 4.0. Students expressed the most improvement in their confidence that they will get a job earn and advanced degree upon graduation (M=4.40) and their awareness of potential careers in machine learning (M=4.31).
Culturally Responsive Teaching

Students were asked to respond to two scales focused on culturally responsive teaching. These scales included the Culturally Responsive Teaching Self-Efficacy Scale (CRTSE) and the Culturally Responsive Teaching Outcome Expectations Scale (CRTOE) (Siwatu, K., 2007). These instruments were developed for preservice teachers and modified for use in college teaching.

Culturally Responsive Teaching Self-Efficacy (CRTSE) –
Students responded to the CRTSE in relation to the instruction they observed in the course. Overall, students perceived the teaching in the course to be culturally responsive with an overall scale average of 3.93 (using a 5-point scale) and all 27 items averaging above 3.5. Students most strongly agreed that their instructors explained new concepts using examples taken from students’ everyday lives (M=4.15), built a sense of trust in students (M=4.16) and developed personal relationships with students (M=4.23). Students at Kentucky reported the highest levels of culturally responsive teaching with an overall average of 4.29 and all but one item exceeding 4.0.

### Culturally Responsive Teaching Self-Efficacy (CRTSE) –

<table>
<thead>
<tr>
<th>Item</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapted instruction to meet the needs of students</td>
<td>4.03 (.948)</td>
<td>4.15 (.785)</td>
<td>4.21 (.976)</td>
<td>3.77 (.973)</td>
</tr>
<tr>
<td>Learned about students’ academic strengths</td>
<td>3.93 (1.031)</td>
<td>4.00 (1.076)</td>
<td>4.26 (.872)</td>
<td>3.59 (1.054)</td>
</tr>
<tr>
<td>Determined whether students prefer working alone or in groups</td>
<td>3.62 (1.213)</td>
<td>3.80 (1.196)</td>
<td>3.63 (1.422)</td>
<td>3.45 (1.057)</td>
</tr>
<tr>
<td>Determined whether students felt comfortable competing with other students</td>
<td>3.78 (1.121)</td>
<td>3.95 (1.234)</td>
<td>4.00 (1.106)</td>
<td>3.43 (.978)</td>
</tr>
<tr>
<td>Identified ways that the school/university culture (e.g. values, norms, and practices) is different from students’ home culture.</td>
<td>3.87 (1.132)</td>
<td>3.70 (1.380)</td>
<td>4.37 (.895)</td>
<td>3.59 (.959)</td>
</tr>
<tr>
<td>Implemented strategies to minimize the effects of the mismatch with the overall school/university culture.</td>
<td>3.74 (1.079)</td>
<td>3.55 (1.191)</td>
<td>4.21 (.918)</td>
<td>3.50 (1.012)</td>
</tr>
<tr>
<td>Assessed student learning using a variety of assessment approaches</td>
<td>3.84 (1.113)</td>
<td>3.85 (1.040)</td>
<td>4.11 (1.049)</td>
<td>3.59 (1.221)</td>
</tr>
<tr>
<td>Built a sense of trust in students</td>
<td>4.16 (.860)</td>
<td>4.05 (.945)</td>
<td>4.58 (.607)</td>
<td>3.91 (.868)</td>
</tr>
<tr>
<td>Used a variety of instructional approaches</td>
<td>3.87 (1.112)</td>
<td>4.05 (1.191)</td>
<td>4.00 (1.138)</td>
<td>3.59 (1.008)</td>
</tr>
<tr>
<td>Developed a community of learners when my class consists of students from diverse backgrounds</td>
<td>4.00 (.856)</td>
<td>3.90 (.912)</td>
<td>4.47 (.612)</td>
<td>3.68 (.839)</td>
</tr>
<tr>
<td>Drew upon students’ cultural background to help make learning meaningful</td>
<td>3.85 (1.078)</td>
<td>3.60 (1.353)</td>
<td>4.32 (.885)</td>
<td>3.68 (.839)</td>
</tr>
</tbody>
</table>

(Continued on Page 26)
Culturally Responsive Teaching

(Continued from Page 25)

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>drew upon students’ prior knowledge to help them make sense of the information</td>
<td>3.98</td>
<td>.885</td>
<td>4.10</td>
<td>.912</td>
<td>4.32</td>
<td>.820</td>
<td>3.59</td>
<td>.796</td>
<td></td>
</tr>
<tr>
<td>learned more about students’ cultural background</td>
<td>3.80</td>
<td>1.077</td>
<td>3.65</td>
<td>1.387</td>
<td>4.32</td>
<td>.749</td>
<td>3.50</td>
<td>.859</td>
<td></td>
</tr>
<tr>
<td>discussed ways in which different cultures made contributions to the field</td>
<td>3.97</td>
<td>1.134</td>
<td>3.84</td>
<td>1.214</td>
<td>4.37</td>
<td>.895</td>
<td>3.73</td>
<td>1.202</td>
<td></td>
</tr>
<tr>
<td>established a class environment that reflects a variety of cultures</td>
<td>3.98</td>
<td>.957</td>
<td>3.80</td>
<td>1.152</td>
<td>4.37</td>
<td>.761</td>
<td>3.82</td>
<td>.853</td>
<td></td>
</tr>
<tr>
<td>developed personal relationships with students</td>
<td>4.23</td>
<td>.824</td>
<td>4.05</td>
<td>.999</td>
<td>4.68</td>
<td>.582</td>
<td>4.00</td>
<td>.690</td>
<td></td>
</tr>
<tr>
<td>understood students’ academic weaknesses</td>
<td>3.87</td>
<td>1.087</td>
<td>3.85</td>
<td>1.182</td>
<td>4.21</td>
<td>1.032</td>
<td>3.59</td>
<td>1.008</td>
<td></td>
</tr>
<tr>
<td>helped students establish positive relationships with other students in class</td>
<td>4.02</td>
<td>.806</td>
<td>3.95</td>
<td>.887</td>
<td>4.37</td>
<td>.761</td>
<td>3.77</td>
<td>.685</td>
<td></td>
</tr>
<tr>
<td>used instructional materials to included representation of cultural groups</td>
<td>3.87</td>
<td>.991</td>
<td>3.65</td>
<td>1.226</td>
<td>4.32</td>
<td>.820</td>
<td>3.68</td>
<td>.780</td>
<td></td>
</tr>
<tr>
<td>show how various cultural groups have used the course content</td>
<td>3.79</td>
<td>1.142</td>
<td>3.65</td>
<td>1.348</td>
<td>4.26</td>
<td>1.046</td>
<td>3.50</td>
<td>.913</td>
<td></td>
</tr>
<tr>
<td>helped students feel like important members of the class</td>
<td>3.98</td>
<td>.975</td>
<td>3.80</td>
<td>1.056</td>
<td>4.47</td>
<td>.697</td>
<td>3.73</td>
<td>.985</td>
<td></td>
</tr>
<tr>
<td>used examples in class that are familiar to students from diverse backgrounds</td>
<td>3.89</td>
<td>1.018</td>
<td>3.80</td>
<td>1.105</td>
<td>4.16</td>
<td>1.119</td>
<td>3.73</td>
<td>.827</td>
<td></td>
</tr>
<tr>
<td>explained new concepts using examples taken from students’ everyday lives</td>
<td>4.15</td>
<td>.910</td>
<td>4.10</td>
<td>1.071</td>
<td>4.47</td>
<td>.697</td>
<td>3.91</td>
<td>.868</td>
<td></td>
</tr>
<tr>
<td>understood student’s’ academic interests</td>
<td>4.07</td>
<td>.854</td>
<td>3.95</td>
<td>1.050</td>
<td>4.47</td>
<td>.697</td>
<td>3.82</td>
<td>.664</td>
<td></td>
</tr>
<tr>
<td>used the interests of students to make learning meaningful for them</td>
<td>4.03</td>
<td>.930</td>
<td>3.95</td>
<td>1.050</td>
<td>4.42</td>
<td>.769</td>
<td>3.77</td>
<td>.869</td>
<td></td>
</tr>
<tr>
<td>implemented cooperative learning activities for those who like to work in groups</td>
<td>4.00</td>
<td>.876</td>
<td>3.90</td>
<td>1.021</td>
<td>4.47</td>
<td>.697</td>
<td>3.68</td>
<td>.716</td>
<td></td>
</tr>
<tr>
<td>designed instruction that matches students’ developmental needs</td>
<td>3.79</td>
<td>1.097</td>
<td>3.75</td>
<td>.967</td>
<td>4.11</td>
<td>1.197</td>
<td>3.55</td>
<td>1.101</td>
<td></td>
</tr>
</tbody>
</table>

Scale (1 = not at all, 5 = A great extent)
Culturally Responsive Teaching Outcome Expectations Scale (CRTOE)

Students’ responses to the CRTOE were in terms of what outcomes they might expect from culturally responsive teaching approaches. Overall, students strongly agreed that culturally responsive teaching would be expected to result in positive outcomes with an overall scale average response of 4.45 (using a 5-point scale). Furthermore, all 20 items averaged 4.0 or above. More specifically, students strongly agreed that when students see themselves in the pictures and examples used in class, they develop a positive self-identity (M=4.52), using a variety of instructional approaches helps students be successful (M=4.54), students are more motivated and engaged when a personal relationship is established between the instructor and student (M=4.55) and students will be successful when instruction is adapted to meet their needs (M=4.57). While the overall sample had positive expectations, average responses from students at Kentucky and Morgan State were slightly higher.

<table>
<thead>
<tr>
<th>Outcome Expectancy Beliefs</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall Scale</strong></td>
<td>4.45</td>
<td>4.28</td>
<td>4.67</td>
<td>4.42</td>
</tr>
<tr>
<td><strong>A positive teacher-student relationship can be established by building a sense of trust in my students.</strong></td>
<td>4.49</td>
<td>4.25</td>
<td>4.89</td>
<td>4.36</td>
</tr>
<tr>
<td><strong>Using a variety of instructional methods will help students be successful.</strong></td>
<td>4.54</td>
<td>4.30</td>
<td>4.95</td>
<td>4.41</td>
</tr>
<tr>
<td><strong>Students will be successful when instruction is adapted to meet their needs.</strong></td>
<td>4.57</td>
<td>4.35</td>
<td>4.84</td>
<td>4.55</td>
</tr>
<tr>
<td><strong>Developing a community of learners promotes positive interactions between students</strong></td>
<td>4.49</td>
<td>4.40</td>
<td>4.68</td>
<td>4.41</td>
</tr>
<tr>
<td><strong>Acknowledging the ways that the school/university culture is different from students’ home culture helps to keep students engaged.</strong></td>
<td>4.38</td>
<td>4.25</td>
<td>4.58</td>
<td>4.32</td>
</tr>
<tr>
<td><strong>It is important to understand and using the communication preferences of my students to minimize communication problems.</strong></td>
<td>4.34</td>
<td>4.15</td>
<td>4.74</td>
<td>4.18</td>
</tr>
<tr>
<td><strong>Connecting students’ prior knowledge with new information will lead to deeper learning.</strong></td>
<td>4.43</td>
<td>4.10</td>
<td>4.74</td>
<td>4.45</td>
</tr>
<tr>
<td><strong>Matching instruction to students’ learning preferences will enhance their learning.</strong></td>
<td>4.44</td>
<td>4.15</td>
<td>4.74</td>
<td>4.45</td>
</tr>
<tr>
<td><strong>Revising instructional materials to include better representation of students’ cultural groups will foster positive self-images.</strong></td>
<td>4.43</td>
<td>4.10</td>
<td>4.58</td>
<td>4.59</td>
</tr>
<tr>
<td><strong>Students will develop an appreciation for their culture when they are taught about the contributions their culture has made.</strong></td>
<td>4.34</td>
<td>4.05</td>
<td>4.42</td>
<td>4.55</td>
</tr>
</tbody>
</table>

(Continued on Page 28)
Culturally Responsive Teaching Outcome Expectations Scale (CRTOE)

(Continued from Page 27)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Scale 1</th>
<th>Scale 2</th>
<th>Scale 3</th>
<th>Scale 4</th>
<th>Scale 5</th>
<th>Scale 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>The likelihood of a student-teacher misunderstanding decreases when students' cultural background is understood.</td>
<td>4.41</td>
<td>.761</td>
<td>4.35</td>
<td>.745</td>
<td>4.53</td>
<td>.841</td>
</tr>
<tr>
<td>Adapting the structure of the class to be compatible with my students' home culture increases student motivation to engage in class.</td>
<td>4.36</td>
<td>.708</td>
<td>4.15</td>
<td>.671</td>
<td>4.42</td>
<td>.769</td>
</tr>
<tr>
<td>Students are more motivated and engaged when a personal relationship is established between the instructor and student.</td>
<td>4.55</td>
<td>.746</td>
<td>4.40</td>
<td>.681</td>
<td>4.63</td>
<td>.955</td>
</tr>
<tr>
<td>Using a variety of assessment approaches provides a better picture of what students have learned.</td>
<td>4.48</td>
<td>.595</td>
<td>4.50</td>
<td>.607</td>
<td>4.63</td>
<td>.496</td>
</tr>
<tr>
<td>Drawing from students' interests when designing instruction increases student motivation to learn.</td>
<td>4.41</td>
<td>.783</td>
<td>4.25</td>
<td>.786</td>
<td>4.63</td>
<td>.684</td>
</tr>
<tr>
<td>Students' self-esteem is enhanced when their cultural background is valued by the instructor.</td>
<td>4.44</td>
<td>.676</td>
<td>4.35</td>
<td>.671</td>
<td>4.68</td>
<td>.582</td>
</tr>
<tr>
<td>Helping students from diverse cultural backgrounds succeed in school will increase their confidence in their academic abilities.</td>
<td>4.44</td>
<td>.719</td>
<td>4.40</td>
<td>.754</td>
<td>4.58</td>
<td>.692</td>
</tr>
<tr>
<td>Students academic achievement will increase when they are provided with unbiased access to learning resources.</td>
<td>4.46</td>
<td>.697</td>
<td>4.35</td>
<td>.745</td>
<td>4.63</td>
<td>.684</td>
</tr>
<tr>
<td>Using culturally familiar examples makes learning new concepts easier.</td>
<td>4.48</td>
<td>.698</td>
<td>4.40</td>
<td>.681</td>
<td>4.68</td>
<td>.671</td>
</tr>
<tr>
<td>When students see themselves in the pictures and examples used in class, they develop a positive self-identity.</td>
<td>4.52</td>
<td>.648</td>
<td>4.40</td>
<td>.681</td>
<td>4.74</td>
<td>.562</td>
</tr>
</tbody>
</table>

5-point agreement scale (SD, D, N, A, SA)
Confidence in Machine Learning Student Learning Outcomes

As might be expected, students were more confident in comparison to what they reported at the beginning of the course, with items averaging approximately 4 or above (using a 5-point scale. Overall, they indicated the greatest confidence in their ability to investigate, clean and visualize data (M=4.15).

<table>
<thead>
<tr>
<th>ML Course SLO</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Scale</td>
<td>Mean: 4.05 SD: .66</td>
<td>Mean: 4.16 SD: .76</td>
<td>Mean: 4.25 SD: .59</td>
<td>Mean: 3.79 SD: .57</td>
</tr>
<tr>
<td>Investigate, clean and visualize data</td>
<td>Mean: 4.15 SD: .833</td>
<td>Mean: 4.20 SD: .768</td>
<td>Mean: 4.21 SD: 1.032</td>
<td>Mean: 4.05 SD: .722</td>
</tr>
<tr>
<td>Understand and frame a problem as a supervised machine learning problem including whether it is a regression or classification problem and to incorporate the application requirements</td>
<td>Mean: 3.95 SD: .902</td>
<td>Mean: 4.25 SD: .786</td>
<td>Mean: 4.11 SD: 1.100</td>
<td>Mean: 3.55 SD: .671</td>
</tr>
<tr>
<td>Apply and tune common machine learning (ML) models in Python by making use of multiple ML toolkits</td>
<td>Mean: 4.07 SD: .793</td>
<td>Mean: 4.15 SD: .875</td>
<td>Mean: 4.37 SD: .597</td>
<td>Mean: 3.73 SD: .767</td>
</tr>
<tr>
<td>Demonstrate the ability to qualitatively and quantitatively evaluate the quality of trained regression and classification models</td>
<td>Mean: 4.05 SD: .845</td>
<td>Mean: 4.15 SD: .933</td>
<td>Mean: 4.32 SD: .749</td>
<td>Mean: 3.73 SD: .767</td>
</tr>
<tr>
<td>Communicate technical concepts (oral and written) for an audience who may have limited technical background</td>
<td>Mean: 4.05 SD: .825</td>
<td>Mean: 4.15 SD: .933</td>
<td>Mean: 4.21 SD: .787</td>
<td>Mean: 3.82 SD: .733</td>
</tr>
<tr>
<td>Identify the potential bias in ML models and explain its implications</td>
<td>Mean: 4.05 SD: .805</td>
<td>Mean: 4.05 SD: .826</td>
<td>Mean: 4.26 SD: .733</td>
<td>Mean: 3.86 SD: .834</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5=A great extent)
At the end of the course, students also expressed higher levels of confidence in their knowledge and ability related to the ABET student learning outcomes with all responses averaging above 4.0. They reported the greatest confidence in relation to understanding their professional and ethical responsibilities (M=4.30), applying knowledge of math, science and engineering (M=4.27), and ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (M=4.27).
Confidence in Machine Learning Units and Topics

Students were asked to indicate the extent to which they confident in their knowledge and ability related to each of the units and topics to be addressed in the Applied Machine Learning Course. Consistent with their confidence in the overall student learning outcomes, students were much more confident in their knowledge and abilities in comparison to the beginning of the course.

<table>
<thead>
<tr>
<th></th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Overall Topics and Units</td>
<td>3.68</td>
<td>.73</td>
<td>3.87</td>
<td>.66</td>
</tr>
<tr>
<td>Computer Science</td>
<td>3.79</td>
<td>1.002</td>
<td>4.00</td>
<td>.918</td>
</tr>
<tr>
<td>Python</td>
<td>3.95</td>
<td>.825</td>
<td>3.95</td>
<td>.887</td>
</tr>
<tr>
<td>Straight Line Equation</td>
<td>3.87</td>
<td>.974</td>
<td>3.90</td>
<td>.912</td>
</tr>
<tr>
<td>Functions</td>
<td>4.02</td>
<td>.940</td>
<td>4.05</td>
<td>.887</td>
</tr>
<tr>
<td>Normal Distribution Props</td>
<td>3.80</td>
<td>.872</td>
<td>4.00</td>
<td>.973</td>
</tr>
<tr>
<td>Hypothesis Testing</td>
<td>3.85</td>
<td>.928</td>
<td>3.95</td>
<td>.887</td>
</tr>
<tr>
<td>Probability and p-values</td>
<td>3.68</td>
<td>1.000</td>
<td>4.11</td>
<td>.809</td>
</tr>
<tr>
<td>Data Science</td>
<td>3.59</td>
<td>.844</td>
<td>3.55</td>
<td>.686</td>
</tr>
<tr>
<td>Types of Machine Learning</td>
<td>3.87</td>
<td>.846</td>
<td>4.00</td>
<td>.725</td>
</tr>
<tr>
<td>Ethical Consequences of Machine Learning</td>
<td>4.18</td>
<td>.847</td>
<td>4.15</td>
<td>.813</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Colab notebooks</td>
<td>4.15</td>
<td>.813</td>
<td>4.30</td>
<td>.733</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Pandas Series and Pandas DataFrames</td>
<td>4.05</td>
<td>.865</td>
<td>3.95</td>
<td>.887</td>
</tr>
<tr>
<td>Visualization of data</td>
<td>4.18</td>
<td>.785</td>
<td>4.25</td>
<td>.716</td>
</tr>
<tr>
<td>Acquiring and downloading data</td>
<td>4.32</td>
<td>.813</td>
<td>4.30</td>
<td>.733</td>
</tr>
<tr>
<td>Exploratory data analysis</td>
<td>4.21</td>
<td>.859</td>
<td>4.40</td>
<td>.754</td>
</tr>
<tr>
<td>Regression analysis</td>
<td>3.75</td>
<td>.943</td>
<td>3.85</td>
<td>.933</td>
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</tbody>
</table>

(Continued on Page 32)
Confidence in Machine Learning Units and Topics

(Continued from Page 31)

<table>
<thead>
<tr>
<th>Topic</th>
<th>Scale 1</th>
<th>Scale 2</th>
<th>Scale 3</th>
<th>Scale 4</th>
<th>Scale 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using scikit-learn for regression analysis</td>
<td>3.82</td>
<td>.904</td>
<td>3.95</td>
<td>.759</td>
<td>4.42</td>
</tr>
<tr>
<td>Using TensorFlow</td>
<td>3.79</td>
<td>.839</td>
<td>3.95</td>
<td>.826</td>
<td>4.21</td>
</tr>
<tr>
<td>Binary Classification methods</td>
<td>3.85</td>
<td>.872</td>
<td>3.95</td>
<td>.945</td>
<td>4.21</td>
</tr>
<tr>
<td>Multiclass Classification</td>
<td>3.79</td>
<td>.878</td>
<td>3.90</td>
<td>.852</td>
<td>4.26</td>
</tr>
<tr>
<td>Image - Video Classification</td>
<td>3.74</td>
<td>.964</td>
<td>4.10</td>
<td>.912</td>
<td>4.05</td>
</tr>
<tr>
<td>Deep Learning</td>
<td>3.68</td>
<td>.937</td>
<td>3.89</td>
<td>.875</td>
<td>4.00</td>
</tr>
<tr>
<td>Recurrent Neural Network</td>
<td>3.49</td>
<td>.994</td>
<td>3.90</td>
<td>.852</td>
<td>3.63</td>
</tr>
<tr>
<td>Natural Language Processing</td>
<td>3.42</td>
<td>1.030</td>
<td>3.65</td>
<td>.875</td>
<td>3.63</td>
</tr>
<tr>
<td>Transfer Learning</td>
<td>3.47</td>
<td>1.065</td>
<td>3.85</td>
<td>.933</td>
<td>3.68</td>
</tr>
<tr>
<td>Clustering</td>
<td>3.59</td>
<td>1.023</td>
<td>3.90</td>
<td>.912</td>
<td>3.95</td>
</tr>
<tr>
<td>k-Means models</td>
<td>3.56</td>
<td>1.025</td>
<td>3.70</td>
<td>.979</td>
<td>4.05</td>
</tr>
<tr>
<td>Embedding</td>
<td>3.48</td>
<td>1.026</td>
<td>3.70</td>
<td>1.031</td>
<td>3.79</td>
</tr>
<tr>
<td>Decision Trees and Random Forest</td>
<td>3.52</td>
<td>1.043</td>
<td>4.00</td>
<td>.858</td>
<td>3.74</td>
</tr>
<tr>
<td>Bayesian Modeling</td>
<td>3.11</td>
<td>1.127</td>
<td>3.45</td>
<td>.945</td>
<td>3.21</td>
</tr>
<tr>
<td>Support Vector Machines (SVM)</td>
<td>3.13</td>
<td>1.087</td>
<td>3.30</td>
<td>.979</td>
<td>3.16</td>
</tr>
<tr>
<td>XG Boost</td>
<td>3.05</td>
<td>1.156</td>
<td>3.35</td>
<td>1.226</td>
<td>3.00</td>
</tr>
<tr>
<td>Activation Functions</td>
<td>3.37</td>
<td>1.008</td>
<td>3.58</td>
<td>.769</td>
<td>3.63</td>
</tr>
<tr>
<td>Big O</td>
<td>3.23</td>
<td>1.198</td>
<td>3.42</td>
<td>1.121</td>
<td>3.53</td>
</tr>
<tr>
<td>Dimensionality Reduction</td>
<td>3.15</td>
<td>1.138</td>
<td>3.55</td>
<td>.826</td>
<td>3.21</td>
</tr>
<tr>
<td>Loss Functions</td>
<td>3.38</td>
<td>1.067</td>
<td>3.75</td>
<td>.786</td>
<td>3.68</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>3.64</td>
<td>1.096</td>
<td>4.05</td>
<td>1.050</td>
<td>3.95</td>
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<tr>
<td>Regular Expressions</td>
<td>3.33</td>
<td>1.130</td>
<td>3.75</td>
<td>1.164</td>
<td>3.33</td>
</tr>
</tbody>
</table>

Scale (1 = Not at all, 5 = A great extent)
**Engineering Self-Efficacy**

In general, students indicated high levels of confidence related to engineering with all but two items averaging 4.0 or above (using a 5-point scale). Overall, students indicated the greatest efficacy related to general engineering (M=4.49) and engineering skills (M=4.41).

<table>
<thead>
<tr>
<th>Engineering Self-Efficacy</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Self-Efficacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can master the content in my major courses</td>
<td>4.57</td>
<td>.590</td>
<td>4.75</td>
<td>.550</td>
</tr>
<tr>
<td>I can master the content in even the most challenging engineering course</td>
<td>4.44</td>
<td>.696</td>
<td>4.50</td>
<td>.688</td>
</tr>
<tr>
<td>I can do good work in my major coursework</td>
<td>4.59</td>
<td>.588</td>
<td>4.55</td>
<td>.686</td>
</tr>
<tr>
<td>I can do an excellent job on engineering-related problems or tasks I am assigned</td>
<td>4.46</td>
<td>.697</td>
<td>4.50</td>
<td>.761</td>
</tr>
<tr>
<td>I can learn the content taught in my engineering-related courses</td>
<td>4.44</td>
<td>.719</td>
<td>4.45</td>
<td>.826</td>
</tr>
<tr>
<td>I can earn good grades in my engineering-related courses</td>
<td>4.43</td>
<td>.805</td>
<td>4.45</td>
<td>.887</td>
</tr>
<tr>
<td>Engineering Skills Self-Efficacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can perform experiments independently</td>
<td>4.34</td>
<td>.750</td>
<td>4.35</td>
<td>.745</td>
</tr>
<tr>
<td>I can analyze data from experiments</td>
<td>4.43</td>
<td>.670</td>
<td>4.45</td>
<td>.759</td>
</tr>
<tr>
<td>I can orally communicate results from experiments</td>
<td>4.33</td>
<td>.811</td>
<td>4.40</td>
<td>.754</td>
</tr>
<tr>
<td>I can communicate results in written form</td>
<td>4.43</td>
<td>.673</td>
<td>4.55</td>
<td>.759</td>
</tr>
<tr>
<td>I can solve problems using a computer</td>
<td>4.51</td>
<td>.649</td>
<td>4.60</td>
<td>.681</td>
</tr>
<tr>
<td>Design Self-Efficacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can design new things</td>
<td>4.27</td>
<td>.71</td>
<td>4.22</td>
<td>.78</td>
</tr>
<tr>
<td>Mean</td>
<td>4.27</td>
<td>.800</td>
<td>4.15</td>
<td>.933</td>
</tr>
</tbody>
</table>

(Continued on Page 34)


Engineering Self-Efficacy

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can identify a design need</td>
<td>4.37</td>
<td>.712</td>
<td>4.35</td>
<td>.745</td>
<td>4.56</td>
<td>.705</td>
<td>4.23</td>
</tr>
<tr>
<td>I can develop design solutions</td>
<td>4.23</td>
<td>.804</td>
<td>4.15</td>
<td>.933</td>
<td>4.42</td>
<td>.769</td>
<td>4.14</td>
</tr>
<tr>
<td>I can evaluate a design</td>
<td>4.31</td>
<td>.807</td>
<td>4.30</td>
<td>.801</td>
<td>4.53</td>
<td>.905</td>
<td>4.14</td>
</tr>
<tr>
<td>I can reorganize changes needed for a design solution to work</td>
<td>4.18</td>
<td>.785</td>
<td>4.15</td>
<td>.875</td>
<td>4.47</td>
<td>.772</td>
<td>3.95</td>
</tr>
<tr>
<td>Tinkering Self-Efficacy</td>
<td>4.13</td>
<td>.82</td>
<td>4.15</td>
<td>.77</td>
<td>4.19</td>
<td>1.01</td>
<td>4.05</td>
</tr>
<tr>
<td>I can work with tools and use them to build things</td>
<td>4.23</td>
<td>.902</td>
<td>4.15</td>
<td>.933</td>
<td>4.53</td>
<td>1.020</td>
<td>4.05</td>
</tr>
<tr>
<td>I can work with tools and use them to fix things</td>
<td>4.23</td>
<td>.902</td>
<td>4.20</td>
<td>.834</td>
<td>4.42</td>
<td>1.071</td>
<td>4.09</td>
</tr>
<tr>
<td>I can work with machines</td>
<td>4.26</td>
<td>.893</td>
<td>4.20</td>
<td>.894</td>
<td>4.47</td>
<td>1.073</td>
<td>4.14</td>
</tr>
<tr>
<td>I can fix machines</td>
<td>3.80</td>
<td>1.138</td>
<td>3.85</td>
<td>1.14</td>
<td>3.79</td>
<td>1.512</td>
<td>3.77</td>
</tr>
<tr>
<td>I can manipulate components and devices</td>
<td>3.98</td>
<td>.991</td>
<td>3.95</td>
<td>.945</td>
<td>3.89</td>
<td>1.370</td>
<td>4.09</td>
</tr>
<tr>
<td>I can assemble things</td>
<td>4.20</td>
<td>.891</td>
<td>4.35</td>
<td>.745</td>
<td>4.11</td>
<td>1.286</td>
<td>4.14</td>
</tr>
<tr>
<td>I can disassemble things</td>
<td>4.18</td>
<td>.940</td>
<td>4.35</td>
<td>.813</td>
<td>4.11</td>
<td>1.286</td>
<td>4.09</td>
</tr>
<tr>
<td>I can apply technical concepts in engineering</td>
<td>4.30</td>
<td>.926</td>
<td>4.35</td>
<td>.875</td>
<td>4.26</td>
<td>1.195</td>
<td>4.29</td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)

(Continued from Page 33)
Persistence

At the end of the course, students indicated a strong intention to persist with 10 of the 14 items averaging 4 or above. More specifically, they indicated that they planned to take courses in their major next year (M=4.69), complete their current degree (M=4.63), continue their education in their current field (M=4.56), get a job in their major field (M=4.70) and working in the field for at least 5 years (M=4.57).

<table>
<thead>
<tr>
<th>Intention to Persist</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Scale</td>
<td>4.20 .65</td>
<td>4.31 .73</td>
<td>4.31 .57</td>
<td>4.01 .62</td>
</tr>
<tr>
<td>Next year, I plan to take courses in my major discipline</td>
<td>4.69 .620</td>
<td>4.75 .550</td>
<td>4.95 .229</td>
<td>4.41 .796</td>
</tr>
<tr>
<td>I intend to get my degree in my current major</td>
<td>4.63 .688</td>
<td>4.65 .745</td>
<td>4.79 .535</td>
<td>4.48 .750</td>
</tr>
<tr>
<td>I am sure that I will continue my education in my major field</td>
<td>4.56 .807</td>
<td>4.75 .550</td>
<td>4.53 .841</td>
<td>4.41 .959</td>
</tr>
<tr>
<td>I intend to get an advanced degree in my major field</td>
<td>4.13 1.103</td>
<td>3.90 1.294</td>
<td>4.42 1.121</td>
<td>4.09 .868</td>
</tr>
<tr>
<td>I plan to pursue and secure an internship this year</td>
<td>4.43 .945</td>
<td>4.58 .769</td>
<td>4.32 1.293</td>
<td>4.41 .734</td>
</tr>
<tr>
<td>I intend to get a job in my major field</td>
<td>4.70 .615</td>
<td>4.70 .571</td>
<td>4.84 .501</td>
<td>4.59 .734</td>
</tr>
<tr>
<td>I can see myself working in my current field for at least 5 years</td>
<td>4.57 .694</td>
<td>4.55 .759</td>
<td>4.63 .597</td>
<td>4.55 .739</td>
</tr>
<tr>
<td>I plan to devote my career to my current major discipline</td>
<td>4.51 .744</td>
<td>4.50 .761</td>
<td>4.58 .692</td>
<td>4.45 .800</td>
</tr>
<tr>
<td>I plan to take additional courses related to machine learning</td>
<td>4.26 .982</td>
<td>4.45 .945</td>
<td>4.42 .769</td>
<td>3.95 1.133</td>
</tr>
<tr>
<td>I intend to seek internship opportunities related to machine learning</td>
<td>4.02 1.118</td>
<td>4.15 1.089</td>
<td>4.21 1.032</td>
<td>3.73 1.202</td>
</tr>
<tr>
<td>I am considering changing my major to something more directly related to machine learning</td>
<td>3.36 1.472</td>
<td>3.70 1.455</td>
<td>3.32 1.565</td>
<td>3.09 1.411</td>
</tr>
<tr>
<td>I plan to pursue an advanced degree related to machine learning</td>
<td>3.56 1.409</td>
<td>3.80 1.436</td>
<td>3.74 1.195</td>
<td>3.18 1.532</td>
</tr>
<tr>
<td>I plan to get a job related to machine learning</td>
<td>3.64 1.239</td>
<td>3.90 1.252</td>
<td>3.63 1.300</td>
<td>3.41 1.182</td>
</tr>
<tr>
<td>I would like to have a career related to machine learning</td>
<td>3.75 1.220</td>
<td>3.95 1.317</td>
<td>3.89 1.150</td>
<td>3.45 1.184</td>
</tr>
</tbody>
</table>

1=Not TRUE of me, 5=VERY TRUE of me
Job Search and Career Preparation Skills

At the end of the course, students indicated a high level of confidence with all items averaging above 3.5 (using a 5-point scale). Students expressed the most confidence in their ability to receive and use feedback from others (M=4.20), prepare for giving a presentation (M=4.11), and apply for internship or job opportunities (M=4.10).
Career Readiness Competencies

At the end of the course, students expressed high levels of confidence in relation to the eight competencies of career readiness in the table below. Overall, students expressed the greatest confidence in their abilities in terms of technology (M=4.30), teamwork (M=4.26), professionalism (M=4.26) and critical thinking (M=4.26).

<table>
<thead>
<tr>
<th>Career Readiness Competencies</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Readiness Scale</td>
<td>4.20 .64</td>
<td>4.18 .68</td>
<td>4.24 .68</td>
<td>4.19 .59</td>
</tr>
<tr>
<td>Career and Self-Development - Awareness of strengths and weaknesses and seek relationships with professionals and opportunities to better prepare you for a career.</td>
<td>4.11 .819</td>
<td>4.00 1.026</td>
<td>4.21 .713</td>
<td>4.14 .710</td>
</tr>
<tr>
<td>Communication - Able to clearly exchange information, ideas, facts, and perspectives with people inside and outside of my current institution or organization.</td>
<td>4.10 .889</td>
<td>4.05 .887</td>
<td>4.05 1.079</td>
<td>4.18 .733</td>
</tr>
<tr>
<td>Critical Thinking - Identify and respond to needs based upon an understanding of the context and a logical analysis of relevant information.</td>
<td>4.28 .777</td>
<td>4.35 .933</td>
<td>4.37 .684</td>
<td>4.14 .710</td>
</tr>
<tr>
<td>Equity and Inclusion - Demonstrate an awareness, attitude, knowledge, and skills required to equitably engage and include people from different cultures.</td>
<td>4.25 .699</td>
<td>4.30 .657</td>
<td>4.42 .692</td>
<td>4.05 .722</td>
</tr>
<tr>
<td>Leadership - Recognize and Capitalize on personal and team strengths to achieve organizational goals.</td>
<td>4.03 .912</td>
<td>3.95 .999</td>
<td>4.00 1.106</td>
<td>4.14 .640</td>
</tr>
<tr>
<td>Professionalism - Knowing work environments differ greatly, understand and demonstrate effective work habits, and act in the interest of the larger community and workplace.</td>
<td>4.26 .772</td>
<td>4.30 .733</td>
<td>4.21 .855</td>
<td>4.27 .767</td>
</tr>
<tr>
<td>Teamwork - Build and maintain collaborative relationships to work effectively toward common goals, while appreciating diverse viewpoints and share responsibilities.</td>
<td>4.26 .854</td>
<td>4.20 .834</td>
<td>4.32 1.057</td>
<td>4.27 .703</td>
</tr>
<tr>
<td>Technology - Understand and leverage technology ethically to enhance efficiency, complete tasks and accomplish goals.</td>
<td>4.30 .715</td>
<td>4.25 .786</td>
<td>4.32 .582</td>
<td>4.32 .780</td>
</tr>
</tbody>
</table>

1-Not at all, 5=A great extent
Career Interests

Finally, students were asked to indicate their interest in specific careers related to machine learning. Of the 10 careers listed below, students expressed the greatest interest in software engineering (M=3.84), software programming (M=3.30) and software development (M=3.79). Students at Kentucky also expressed great interest in a career as a machine learning engineer (M=4.21).

<table>
<thead>
<tr>
<th>Career Interests</th>
<th>Overall Sample (N=62)</th>
<th>Arkansas (n=20)</th>
<th>Kentucky (n=19)</th>
<th>Morgan State (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Software Engineer</td>
<td>3.84</td>
<td>1.214</td>
<td>4.10</td>
<td>.718</td>
</tr>
<tr>
<td>Software Programmer</td>
<td>3.80</td>
<td>1.219</td>
<td>4.05</td>
<td>.945</td>
</tr>
<tr>
<td>Software Developer</td>
<td>3.79</td>
<td>1.226</td>
<td>4.05</td>
<td>.945</td>
</tr>
<tr>
<td>Data Scientist</td>
<td>3.54</td>
<td>1.119</td>
<td>3.70</td>
<td>.923</td>
</tr>
<tr>
<td>Computer Engineer</td>
<td>3.46</td>
<td>1.246</td>
<td>3.65</td>
<td>1.040</td>
</tr>
<tr>
<td>Artificial Intelligence Research Scientist</td>
<td>3.59</td>
<td>1.116</td>
<td>3.85</td>
<td>.813</td>
</tr>
<tr>
<td>Cloud Engineer</td>
<td>3.22</td>
<td>1.250</td>
<td>3.25</td>
<td>1.118</td>
</tr>
<tr>
<td>Machine Learning Scientist</td>
<td>3.39</td>
<td>1.269</td>
<td>3.55</td>
<td>1.276</td>
</tr>
<tr>
<td>Machine Learning Engineer</td>
<td>3.56</td>
<td>1.285</td>
<td>3.75</td>
<td>1.293</td>
</tr>
<tr>
<td>Big Data Engineer</td>
<td>3.26</td>
<td>1.223</td>
<td>3.45</td>
<td>1.395</td>
</tr>
</tbody>
</table>

1=Not at all interested, 5=Very interested
Pre-Post Course Change

Finally, comparisons were made from the pre course to post course survey administrations using a matched sample. These comparisons are summarized in the table below. All averages were higher at the end of the course, indicating improvement. Of the 11 comparisons summarized below, 9 reached the minimum criteria for statistical significance (< .05). These comparisons were also examined in terms of magnitude (effect size) with 2 large effects for changes directly related to the machine learning course. That is, students significantly improved their confidence in meeting the ML course student learning outcomes and their confidence related to the course units. In addition, students also reported significant higher engineering efficacy, confidence in meeting the ABET SLOs and persistence at the end of the course.

<table>
<thead>
<tr>
<th>Scale</th>
<th>N</th>
<th>Pre Course</th>
<th>Post Course</th>
<th>t (p)</th>
<th>Effect Size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML Course SLOs</td>
<td>59</td>
<td>2.21 (.94)</td>
<td>4.04 (.67)</td>
<td>14.22 (&lt;.001)</td>
<td>1.87</td>
</tr>
<tr>
<td>ABET SLOs</td>
<td>58</td>
<td>3.69 (.83)</td>
<td>4.18 (.63)</td>
<td>4.5 (&lt; .001)</td>
<td>.591</td>
</tr>
<tr>
<td>MK Course Unit Confidence</td>
<td>59</td>
<td>2.17 (.73)</td>
<td>3.67 (.74)</td>
<td>14.35 (&lt;.001)</td>
<td>1.87</td>
</tr>
<tr>
<td>Engineering Efficacy – Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Skills</td>
<td>59</td>
<td>3.99 (.61)</td>
<td>4.32 (.59)</td>
<td>4.18 (&lt;.001)</td>
<td>.544</td>
</tr>
<tr>
<td>Skills</td>
<td>59</td>
<td>4.21 (.60)</td>
<td>4.49 (.60)</td>
<td>3.32 (&lt;.001)</td>
<td>.432</td>
</tr>
<tr>
<td>Design</td>
<td>59</td>
<td>4.14 (.65)</td>
<td>4.42 (.58)</td>
<td>3.55 (&lt;.001)</td>
<td>.463</td>
</tr>
<tr>
<td>Tinkering</td>
<td>59</td>
<td>3.88 (.78)</td>
<td>4.27 (.71)</td>
<td>4.14 (&lt;.001)</td>
<td>.539</td>
</tr>
<tr>
<td>Persistence</td>
<td>59</td>
<td>3.79 (.92)</td>
<td>4.13 (.82)</td>
<td>3.09 (.002)</td>
<td>.402</td>
</tr>
<tr>
<td>Engineering Efficacy – General</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skills</td>
<td>59</td>
<td>3.99 (.61)</td>
<td>4.32 (.59)</td>
<td>4.18 (&lt;.001)</td>
<td>.544</td>
</tr>
<tr>
<td>Design</td>
<td>59</td>
<td>4.21 (.60)</td>
<td>4.49 (.60)</td>
<td>3.32 (&lt;.001)</td>
<td>.432</td>
</tr>
<tr>
<td>Tinkering</td>
<td>59</td>
<td>4.14 (.65)</td>
<td>4.42 (.58)</td>
<td>3.55 (&lt;.001)</td>
<td>.463</td>
</tr>
<tr>
<td>Career Development Units</td>
<td>58</td>
<td>3.91 (.76)</td>
<td>3.99 (.80)</td>
<td>.767 (.223)</td>
<td>.101</td>
</tr>
<tr>
<td>Career Readiness</td>
<td>59</td>
<td>4.08 (.69)</td>
<td>4.22 (.64)</td>
<td>1.58 (.060)</td>
<td>.205</td>
</tr>
</tbody>
</table>

a-.2=small, .5=medium, .8=large
Follow-up Pre-Post Comparisons

Follow-up comparisons were made on items from each of the scales that resulted in a statistically significant improvement. Confidence in Machine Learning Student Learning Outcomes - Means and standard deviations for each of the course student learning outcomes are summarized below for the matched sample of 59 students. Each of the six comparisons was statistically significant with students reporting greater confidence in their ability at the end of the course.

<table>
<thead>
<tr>
<th>ML Course SLO</th>
<th>Pre Course (n=59)</th>
<th>Post Course (n=59)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Scale</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Investigate, clean and visualize data</td>
<td>2.92</td>
<td>1.263</td>
<td>4.15</td>
</tr>
<tr>
<td>Understand and frame a problem as a supervised machine learning problem including whether it is a regression or classification problem and to incorporate the application requirements</td>
<td>2.05</td>
<td>1.166</td>
<td>3.95</td>
</tr>
<tr>
<td>Apply and tune common machine learning (ML) models in Python by making use of multiple ML toolkits</td>
<td>1.78</td>
<td>1.052</td>
<td>4.05</td>
</tr>
<tr>
<td>Demonstrate the ability to qualitatively and quantitatively evaluate the quality of trained regression and classification models</td>
<td>1.95</td>
<td>1.090</td>
<td>4.03</td>
</tr>
<tr>
<td>Communicate technical concepts (oral and written) for an audience who may have limited technical background</td>
<td>2.68</td>
<td>1.319</td>
<td>4.05</td>
</tr>
<tr>
<td>Identify the potential bias in ML models and explain its implications</td>
<td>1.86</td>
<td>.991</td>
<td>4.03</td>
</tr>
<tr>
<td>Scale (1=Not at all, 5=A great extent)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*p&lt;.05, **p&lt;.01, *** p &lt;.001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Confidence in ABET Student Learning Outcomes

As with the course SLOs, students’ confidence related to the 11 ABET SLOs was compared from pre course to post course. Students reported greater confidence for each of these SLOs at the end of the course. Of the 11, 9 were statistically significant.

<table>
<thead>
<tr>
<th>ABET SLO</th>
<th>Pre Course (N=58)</th>
<th>Post Course (n=58)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Scale</td>
<td>3.69 .83</td>
<td>4.18 .63</td>
<td></td>
</tr>
<tr>
<td>Apply knowledge of mathematics, science and engineering</td>
<td>3.66 1.027</td>
<td>4.26 .762</td>
<td>4.642***</td>
</tr>
<tr>
<td>Design and conduct experiments and interpret the resulting data</td>
<td>3.48 1.186</td>
<td>4.17 .775</td>
<td>4.081**</td>
</tr>
<tr>
<td>Design a system, component, or process to meet desired needs</td>
<td>3.39 1.175</td>
<td>4.00 .898</td>
<td>3.843***</td>
</tr>
<tr>
<td>Work effectively on a multidisciplinary team</td>
<td>3.92 1.094</td>
<td>4.14 .895</td>
<td>1.196</td>
</tr>
<tr>
<td>Identify, formulate and solve engineering problems</td>
<td>3.42 1.037</td>
<td>4.12 .751</td>
<td>4.810***</td>
</tr>
<tr>
<td>Understand professional and ethical responsibility</td>
<td>3.98 1.042</td>
<td>4.29 .726</td>
<td>2.023*</td>
</tr>
<tr>
<td>Communicate effectively</td>
<td>4.14 .907</td>
<td>4.16 .875</td>
<td>.248</td>
</tr>
<tr>
<td>Understand the broad impact of engineering solutions in a global, economic, environmental and social context</td>
<td>3.65 1.087</td>
<td>4.19 .826</td>
<td>3.539***</td>
</tr>
<tr>
<td>Recognize the need for and ability to engage in professional development/improvement</td>
<td>3.87 .999</td>
<td>4.26 .739</td>
<td>3.297**</td>
</tr>
<tr>
<td>Understanding and awareness of contemporary issues</td>
<td>3.65 .988</td>
<td>4.12 .803</td>
<td>3.643***</td>
</tr>
<tr>
<td>Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.</td>
<td>3.60 1.028</td>
<td>4.26 .785</td>
<td>4.406***</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, S=A great extent)  
*p<.05, **p<.01, ***p <.001
Confidence in Machine Learning Units and Topics

Follow-up comparisons for each of the 39 topics summarized below yielded statistically significant improvement in student confidence for all but one. That unit was the unit on functions for which students expressed a high level of confidence prior to the course and maintained that confidence throughout the course.

<table>
<thead>
<tr>
<th>Topic</th>
<th>(N=59) Mean</th>
<th>SD</th>
<th>(n=59) Mean</th>
<th>SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Topics and Units</td>
<td>2.17</td>
<td>.73</td>
<td>3.67</td>
<td>.74</td>
<td></td>
</tr>
<tr>
<td>Computer Science</td>
<td>3.07</td>
<td>1.127</td>
<td>3.78</td>
<td>1.018</td>
<td>5.188***</td>
</tr>
<tr>
<td>Python</td>
<td>2.70</td>
<td>1.183</td>
<td>3.93</td>
<td>.828</td>
<td>8.778***</td>
</tr>
<tr>
<td>Straight Line Equation</td>
<td>3.07</td>
<td>1.461</td>
<td>3.86</td>
<td>.973</td>
<td>3.657***</td>
</tr>
<tr>
<td>Functions</td>
<td>3.72</td>
<td>1.091</td>
<td>4.00</td>
<td>.947</td>
<td>1.932</td>
</tr>
<tr>
<td>Matrix Algebra</td>
<td>2.73</td>
<td>1.201</td>
<td>3.54</td>
<td>1.039</td>
<td>4.733***</td>
</tr>
<tr>
<td>Normal Distribution Properties</td>
<td>2.87</td>
<td>1.268</td>
<td>3.78</td>
<td>.872</td>
<td>5.138***</td>
</tr>
<tr>
<td>Hypothesis Testing</td>
<td>3.12</td>
<td>1.274</td>
<td>3.83</td>
<td>.931</td>
<td>4.434***</td>
</tr>
<tr>
<td>Probability and p-values</td>
<td>2.93</td>
<td>1.255</td>
<td>3.71</td>
<td>.991</td>
<td>4.910***</td>
</tr>
<tr>
<td>Data Science</td>
<td>2.39</td>
<td>1.017</td>
<td>3.59</td>
<td>.853</td>
<td>7.676***</td>
</tr>
<tr>
<td>Types of Machine Learning (ML) Models</td>
<td>1.78</td>
<td>.930</td>
<td>3.86</td>
<td>.860</td>
<td>14.486***</td>
</tr>
<tr>
<td>Ethical Consequences of Machine Learning</td>
<td>2.16</td>
<td>1.225</td>
<td>4.17</td>
<td>.854</td>
<td>11.619***</td>
</tr>
<tr>
<td>Data Analysis and Manipulation - Colab notebooks</td>
<td>1.93</td>
<td>1.096</td>
<td>4.14</td>
<td>.819</td>
<td>12.533***</td>
</tr>
<tr>
<td>Data Analysis and Manipulation -Panda Series and Panda DataFrames</td>
<td>1.76</td>
<td>1.056</td>
<td>4.03</td>
<td>.870</td>
<td>13.391***</td>
</tr>
<tr>
<td>Visualization of data</td>
<td>2.75</td>
<td>1.195</td>
<td>4.17</td>
<td>.791</td>
<td>8.085***</td>
</tr>
<tr>
<td>Acquiring and downloading data</td>
<td>2.91</td>
<td>1.204</td>
<td>4.31</td>
<td>.821</td>
<td>8.370***</td>
</tr>
<tr>
<td>Exploratory data analysis</td>
<td>2.34</td>
<td>1.092</td>
<td>4.22</td>
<td>.872</td>
<td>11.230***</td>
</tr>
<tr>
<td>Regression analysis</td>
<td>2.19</td>
<td>1.224</td>
<td>3.75</td>
<td>.958</td>
<td>8.015***</td>
</tr>
<tr>
<td>Using scikit-learn for regression analysis</td>
<td>1.67</td>
<td>.980</td>
<td>3.80</td>
<td>.906</td>
<td>12.213***</td>
</tr>
<tr>
<td>Using TensorFlow</td>
<td>1.47</td>
<td>.838</td>
<td>3.78</td>
<td>.852</td>
<td>16.410***</td>
</tr>
<tr>
<td>Binary Classification methods</td>
<td>1.88</td>
<td>1.093</td>
<td>3.86</td>
<td>.880</td>
<td>11.874***</td>
</tr>
<tr>
<td>Multiclass Classification</td>
<td>1.83</td>
<td>1.157</td>
<td>3.80</td>
<td>.886</td>
<td>11.030***</td>
</tr>
<tr>
<td>Image - Video Classification</td>
<td>1.68</td>
<td>1.003</td>
<td>3.73</td>
<td>.980</td>
<td>11.328***</td>
</tr>
<tr>
<td>Deep Learning</td>
<td>1.86</td>
<td>1.131</td>
<td>3.67</td>
<td>.951</td>
<td>9.813***</td>
</tr>
</tbody>
</table>
Confidence in Machine Learning Units and Topics

(Continued from Page 42)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Scale</th>
<th>Confidence</th>
<th>Complexity</th>
<th>Usability</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recurrent Neural Network</td>
<td>1.58</td>
<td>.969</td>
<td>3.47</td>
<td>1.006</td>
<td>11.051***</td>
</tr>
<tr>
<td>Natural Language Processing</td>
<td>1.79</td>
<td>1.088</td>
<td>3.38</td>
<td>1.023</td>
<td>8.608***</td>
</tr>
<tr>
<td>Transfer Learning</td>
<td>1.53</td>
<td>.941</td>
<td>3.45</td>
<td>1.079</td>
<td>11.300***</td>
</tr>
<tr>
<td>Clustering</td>
<td>1.83</td>
<td>1.117</td>
<td>3.58</td>
<td>1.037</td>
<td>10.182***</td>
</tr>
<tr>
<td>k-Means models</td>
<td>1.71</td>
<td>.991</td>
<td>3.54</td>
<td>1.039</td>
<td>11.384***</td>
</tr>
<tr>
<td>Embedding</td>
<td>1.84</td>
<td>1.141</td>
<td>3.47</td>
<td>1.040</td>
<td>9.518***</td>
</tr>
<tr>
<td>Decision Trees and Random Forest</td>
<td>1.81</td>
<td>1.083</td>
<td>3.54</td>
<td>1.056</td>
<td>9.666***</td>
</tr>
<tr>
<td>Bayesian Modeling</td>
<td>1.59</td>
<td>1.060</td>
<td>3.10</td>
<td>1.140</td>
<td>8.679***</td>
</tr>
<tr>
<td>Support Vector Machines (SVM)</td>
<td>1.42</td>
<td>.835</td>
<td>3.12</td>
<td>1.100</td>
<td>10.106***</td>
</tr>
<tr>
<td>XG Boost</td>
<td>1.33</td>
<td>.758</td>
<td>3.05</td>
<td>1.161</td>
<td>10.543***</td>
</tr>
<tr>
<td>Activation Functions</td>
<td>1.54</td>
<td>.953</td>
<td>3.40</td>
<td>1.008</td>
<td>11.562***</td>
</tr>
<tr>
<td>Big O</td>
<td>2.17</td>
<td>1.353</td>
<td>3.21</td>
<td>1.210</td>
<td>6.284***</td>
</tr>
<tr>
<td>Dimensionality Reduction</td>
<td>1.49</td>
<td>.898</td>
<td>3.12</td>
<td>1.146</td>
<td>9.851***</td>
</tr>
<tr>
<td>Loss Functions</td>
<td>1.60</td>
<td>1.033</td>
<td>3.36</td>
<td>1.079</td>
<td>10.722***</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>3.03</td>
<td>1.326</td>
<td>3.63</td>
<td>1.113</td>
<td>3.856***</td>
</tr>
<tr>
<td>Regular Expressions</td>
<td>2.80</td>
<td>1.270</td>
<td>3.34</td>
<td>1.148</td>
<td>2.690**</td>
</tr>
</tbody>
</table>

Scale (1=Not at all, 5= A great extent)
*p<.05, **p<.01, *** p <.001
Engineering Self-Efficacy

Comparisons for each item from the Engineering Self Efficacy scale are summarized below. Statistically significant improvement resulted for 17 of the 24 items. These significant improvements included all 5 items related to engineering design, 6 of the 8 items from the tinkering subscale, 3 of the 5 related to skills and 3 of the 6 related to general efficacy.

<table>
<thead>
<tr>
<th></th>
<th>Pre Course (N=59)</th>
<th>Post Course (n=59)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engineering Self-Efficacy</strong></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>General Self-Efficacy</td>
<td>4.21</td>
<td>.60</td>
</tr>
<tr>
<td>I can master the content in my major courses</td>
<td>4.25</td>
<td>.709</td>
</tr>
<tr>
<td>I can master the content in even the most challenging engineering course</td>
<td>3.78</td>
<td>.904</td>
</tr>
<tr>
<td>I can do good work in my major coursework</td>
<td>4.38</td>
<td>.761</td>
</tr>
<tr>
<td>I can do an excellent job on engineering-related problems or tasks I am assigned</td>
<td>4.20</td>
<td>.732</td>
</tr>
<tr>
<td>I can learn the content taught in my engineering-related courses</td>
<td>4.37</td>
<td>.688</td>
</tr>
<tr>
<td>I can earn good grades in my engineering-related courses</td>
<td>4.30</td>
<td>.720</td>
</tr>
<tr>
<td>I can perform experiments independently</td>
<td>3.85</td>
<td>.954</td>
</tr>
<tr>
<td>I can analyze data from experiments</td>
<td>4.15</td>
<td>.820</td>
</tr>
<tr>
<td>I can orally communicate results from experiments</td>
<td>4.18</td>
<td>.833</td>
</tr>
<tr>
<td>I can communicate results in written form</td>
<td>4.25</td>
<td>.795</td>
</tr>
<tr>
<td>I can solve problems using a computer</td>
<td>4.30</td>
<td>.788</td>
</tr>
<tr>
<td>I can design new things</td>
<td>4.00</td>
<td>.902</td>
</tr>
<tr>
<td>I can identify a design need</td>
<td>3.83</td>
<td>.847</td>
</tr>
<tr>
<td>I can develop design solutions</td>
<td>3.93</td>
<td>.821</td>
</tr>
<tr>
<td>I can evaluate a design</td>
<td>3.88</td>
<td>.865</td>
</tr>
<tr>
<td>I can reorganize changes needed for a design solution to work</td>
<td>3.78</td>
<td>.885</td>
</tr>
<tr>
<td>I can work with tools and use them to build things</td>
<td>3.88</td>
<td>1.010</td>
</tr>
<tr>
<td>I can work with tools and use them to fix things</td>
<td>3.93</td>
<td>.936</td>
</tr>
<tr>
<td>I can work with machines</td>
<td>3.90</td>
<td>1.130</td>
</tr>
<tr>
<td>I can fix machines</td>
<td>3.27</td>
<td>1.163</td>
</tr>
<tr>
<td>I can manipulate components and devices</td>
<td>3.66</td>
<td>.976</td>
</tr>
<tr>
<td>I can assemble things</td>
<td>4.02</td>
<td>1.000</td>
</tr>
<tr>
<td>I can disassemble things</td>
<td>3.97</td>
<td>1.104</td>
</tr>
<tr>
<td>I can apply technical concepts in engineering</td>
<td>3.87</td>
<td>1.049</td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
### Persistence

Students came into the course with high levels of persistence and maintained or slightly improved over the 8 weeks. At the end of the course, students indicated significantly greater intent to get a job in their field, take additional courses related to machine learning, and to consider changing my major to something more directly related to machine learning.

<table>
<thead>
<tr>
<th>Intention to Persist</th>
<th>Pre Course (N=59)</th>
<th>Post Course (n=59)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall Scale</strong></td>
<td>4.02 .57</td>
<td>4.19 .66</td>
<td></td>
</tr>
<tr>
<td>Next year, I plan to take courses in my major discipline</td>
<td>4.51 .774</td>
<td>4.68 .628</td>
<td>1.457</td>
</tr>
<tr>
<td>I intend to get my degree in my current major</td>
<td>4.54 .750</td>
<td>4.64 .693</td>
<td>1.062</td>
</tr>
<tr>
<td>I am sure that I will continue my education in my major field</td>
<td>4.56 .702</td>
<td>4.56 .815</td>
<td>.000</td>
</tr>
<tr>
<td>I intend to get an advanced degree in my major field</td>
<td>4.03 .909</td>
<td>4.12 1.115</td>
<td>.433</td>
</tr>
<tr>
<td>I plan to pursue and secure an internship this year.</td>
<td>4.32 .854</td>
<td>4.41 .956</td>
<td>.739</td>
</tr>
<tr>
<td>I intend to get a job in my major field</td>
<td>4.43 .831</td>
<td>4.69 .623</td>
<td>2.348*</td>
</tr>
<tr>
<td>I can see myself working in my current field for at least 5 years.</td>
<td>4.51 .728</td>
<td>4.58 .700</td>
<td>.629</td>
</tr>
<tr>
<td>I plan to devote my career to my current major discipline</td>
<td>4.43 .767</td>
<td>4.51 .751</td>
<td>.600</td>
</tr>
<tr>
<td>I plan to take additional courses related to machine learning.</td>
<td>3.90 1.053</td>
<td>4.25 .993</td>
<td>1.991*</td>
</tr>
<tr>
<td>I intend to seek internship opportunities related to machine learning</td>
<td>3.88 1.043</td>
<td>4.00 1.130</td>
<td>.687</td>
</tr>
<tr>
<td>I am considering changing my major to something more directly related to machine learning</td>
<td>2.93 1.096</td>
<td>3.36 1.494</td>
<td>1.969*</td>
</tr>
<tr>
<td>I plan to pursue an advanced degree related to machine learning</td>
<td>3.20 1.132</td>
<td>3.53 1.419</td>
<td>1.634</td>
</tr>
<tr>
<td>I plan to get a job related to machine learning</td>
<td>3.52 1.081</td>
<td>3.63 1.258</td>
<td>.597</td>
</tr>
<tr>
<td>I would like to have a career related to machine learning</td>
<td>3.52 .983</td>
<td>3.73 1.229</td>
<td>1.272</td>
</tr>
</tbody>
</table>

1=Not TRUE of me, 5=VERY TRUE of me

*p<.05, **p<.01, ***p <.001
### University of Arkansas

Over the duration of the course, students from the University of Arkansas reported improvement for 10 of the 11 scales summarized below with statistically significant improvement related to the course SLOs, ABET SLOs and confidence in the course content topic areas.

<table>
<thead>
<tr>
<th>Scale</th>
<th>N</th>
<th>Pre Course</th>
<th>Post Course</th>
<th>t (p)</th>
<th>Effect Size (Cohen's d)a</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML Course SLOs</td>
<td>20</td>
<td>2.41 (.12)</td>
<td>4.16 (.76)</td>
<td>7.29***</td>
<td>1.63</td>
</tr>
<tr>
<td>ABET SLOs</td>
<td>20</td>
<td>3.86 (.87)</td>
<td>4.32 (.68)</td>
<td>2.36*</td>
<td>.527</td>
</tr>
<tr>
<td>MK Course Unit Confidence</td>
<td>20</td>
<td>2.33 (.85)</td>
<td>3.87 (.66)</td>
<td>11.12***</td>
<td>2.49</td>
</tr>
<tr>
<td>Engineering Efficacy - Total</td>
<td>20</td>
<td>4.12 (.56)</td>
<td>4.33 (.66)</td>
<td>1.53</td>
<td>.343</td>
</tr>
<tr>
<td>General</td>
<td>20</td>
<td>4.30 (.55)</td>
<td>4.53 (.67)</td>
<td>1.28</td>
<td>.286</td>
</tr>
<tr>
<td>Skills</td>
<td>20</td>
<td>4.21 (.63)</td>
<td>4.47 (.59)</td>
<td>1.62</td>
<td>.363</td>
</tr>
<tr>
<td>Design</td>
<td>20</td>
<td>4.03 (.67)</td>
<td>4.22 (.78)</td>
<td>1.16</td>
<td>.260</td>
</tr>
<tr>
<td>Tinkering</td>
<td>20</td>
<td>3.98 (.71)</td>
<td>4.15 (.77)</td>
<td>1.17</td>
<td>.262</td>
</tr>
<tr>
<td>Persistence</td>
<td>20</td>
<td>4.01 (.64)</td>
<td>4.31 (.73)</td>
<td>1.59</td>
<td>.356</td>
</tr>
</tbody>
</table>

* p<.05, **p<.01, ***p<.001
a: .2=small, .5=medium, .8=large

### University of Kentucky

Over the duration of the course, students from the University of Kentucky reported improvement for each of the 11 scales summarized below with statistically significant improvement related to the course SLOs, ABET SLOs, confidence in the course content topic areas, engineering efficacy and career readiness.

<table>
<thead>
<tr>
<th>Scale</th>
<th>N</th>
<th>Pre Course</th>
<th>Post Course</th>
<th>t (p)</th>
<th>Effect Size (Cohen's d)a</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML Course SLOs</td>
<td>17</td>
<td>2.31 (.89)</td>
<td>4.25 (.63)</td>
<td>7.51***</td>
<td>1.82</td>
</tr>
<tr>
<td>ABET SLOs</td>
<td>17</td>
<td>3.56 (.89)</td>
<td>4.34 (.59)</td>
<td>3.69**</td>
<td>.923</td>
</tr>
<tr>
<td>MK Course Unit Confidence</td>
<td>17</td>
<td>2.24 (.73)</td>
<td>3.99 (.62)</td>
<td>8.89***</td>
<td>2.16</td>
</tr>
<tr>
<td>Engineering Efficacy - Total</td>
<td>17</td>
<td>3.85 (.52)</td>
<td>4.46 (.62)</td>
<td>3.86**</td>
<td>.937</td>
</tr>
<tr>
<td>General</td>
<td>17</td>
<td>4.23 (.58)</td>
<td>4.61 (.55)</td>
<td>2.74*</td>
<td>.644</td>
</tr>
<tr>
<td>Skills</td>
<td>17</td>
<td>4.10 (.60)</td>
<td>4.64 (.48)</td>
<td>3.99**</td>
<td>.967</td>
</tr>
<tr>
<td>Design</td>
<td>17</td>
<td>3.85 (.77)</td>
<td>4.48 (.77)</td>
<td>3.79**</td>
<td>.921</td>
</tr>
<tr>
<td>Tinkering</td>
<td>17</td>
<td>3.42 (.99)</td>
<td>4.22 (1.11)</td>
<td>3.68**</td>
<td>.892</td>
</tr>
<tr>
<td>Persistence</td>
<td>17</td>
<td>4.00 (.56)</td>
<td>4.28 (.60)</td>
<td>1.78</td>
<td>.432</td>
</tr>
<tr>
<td>Career Development Units</td>
<td>16</td>
<td>3.67 (.95)</td>
<td>4.04 (.86)</td>
<td>1.93</td>
<td>.468</td>
</tr>
<tr>
<td>Career Readiness</td>
<td>17</td>
<td>3.84 (.79)</td>
<td>4.31 (.67)</td>
<td>3.13**</td>
<td>.760</td>
</tr>
</tbody>
</table>

* p<.05, **p<.01, ***p<.001
a: .2=small, .5=medium, .8=large
### Changes over time by Site

**Morgan State University** - Over the duration of the course, students from the University of Kentucky reported improvement for 8 of the 11 scales summarized below with statistically significant improvement related to the course SLOs, confidence in the course content topic areas, and general and design engineering efficacy.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Pre Course</th>
<th>Post Course</th>
<th>t (p)</th>
<th>Effect Size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ML Course SLOs</strong></td>
<td>22</td>
<td>1.96 (.76)</td>
<td>3.79 (.57)</td>
<td>10.18***</td>
</tr>
<tr>
<td><strong>ABET SLOs</strong></td>
<td>22</td>
<td>3.61 (.76)</td>
<td>3.94 (.57)</td>
<td>1.92</td>
</tr>
<tr>
<td><strong>MK Course Unit Confidence</strong></td>
<td>22</td>
<td>1.97 (.59)</td>
<td>3.23 (.75)</td>
<td>6.58***</td>
</tr>
<tr>
<td><strong>Engineering Efficacy - Total</strong></td>
<td>22</td>
<td>3.99 (.72)</td>
<td>4.19 (.49)</td>
<td>2.07</td>
</tr>
<tr>
<td><strong>General Skills</strong></td>
<td>22</td>
<td>4.12 (.68)</td>
<td>4.35 (.58)</td>
<td>2.17*</td>
</tr>
<tr>
<td><strong>Skills</strong></td>
<td>22</td>
<td>4.10 (.73)</td>
<td>4.21 (.59)</td>
<td>1.03</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>22</td>
<td>3.77 (.89)</td>
<td>4.14 (.58)</td>
<td>2.49*</td>
</tr>
<tr>
<td><strong>Tinkering</strong></td>
<td>22</td>
<td>3.94 (.97)</td>
<td>4.05 (.59)</td>
<td>.683</td>
</tr>
<tr>
<td><strong>Persistence</strong></td>
<td>22</td>
<td>4.04 (.53)</td>
<td>4.01 (.62)</td>
<td>-.169</td>
</tr>
<tr>
<td><strong>Career Development Units</strong></td>
<td>22</td>
<td>4.01 (.67)</td>
<td>3.97 (.73)</td>
<td>-.352</td>
</tr>
<tr>
<td><strong>Career Readiness</strong></td>
<td>22</td>
<td>4.24 (.55)</td>
<td>4.19 (.59)</td>
<td>-.451</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01, ***p<.001
.a-.2=small, .5=medium, .8=large
Focus Group Summary

Focus groups were conducted with students from each of the three institutions during the week of July 18th. All focus groups were conducted virtually, using Zoom.

The primary purpose of these focus groups was to learn more from students about their overall experiences in the course, interactions with other students and faculty, and suggestions to better serve students taking this course.

Overall, students indicated that the overall course was a valuable learning experience. They described it as intense, challenging and fast-paced. Students described the course environment as very collaborative and consistently indicated that one of the most beneficial aspects of the course has been meeting and working collaboratively with their peers from different disciplines. They indicated that the sessions in which a faculty member was present were better than those they watched remotely, but also described the TAs as valuable in helping them. Students offered several suggestions related to the course.

Course Organization and Expectations - Students from each site described that course expectations and details related to required assignments could be more clearly communicated. They suggested an orientation to the class and syllabus so students understand what is expected. They also suggested using a learning management system (LMS) to organize course activities, materials and assignments. There are helpful organizational features within these LMS such as a dashboard that alert participants (students, TAs and instructors) of the course schedule and when upcoming assignments are due. LMS also offer a way to organize course materials and store completed assignments and feedback that might be helpful to review when working on subsequent tasks.

Pre-requisites and Remedial Opportunities - Students indicated that having more experience with programming, statistics and linear Algebra would be beneficial for this course. While some students came in with this experience, others did not. Several students described that they struggled a bit to learn the necessary programming and other background skills to do the work in a timely manner. Students sought help from other students and online resources to try and catch up and keep up with assignments. Students suggested building in opportunities (and perhaps some extra days) for students to engage with more applied examples, resources and get feedback would be very helpful.

Course Projects - Students describing working on projects with other students from diverse backgrounds in terms of race, ethnicity, academic major and academic level. Students described the opportunities they have to work with their peers have been among the most valuable aspect of the course. Working with (and learning from) students in their groups promotes collaboration and teamwork and prepares them for careers in which they will work on projects as part of interdisciplinary teams.

The primary suggestion made was to continue this, but structure teams so that there are students with different backgrounds working together. Also, students want more choices related to the nature of projects on which they work. Also, they suggested introducing the capstone project much earlier in the course so they are better prepared to complete it.
Weekly Feedback Summary

Feedback was gathered each week for weeks 1 to 6. Each week, students responded to items related to the weekly unit objectives, quality of instruction and value of the professional development.

Weekly Objectives – Confidence in Knowledge and Ability
A summary of student responses to their confidence in the weekly objectives is provided below. Generally, as weeks progressed, content became more challenging. While average responses declined slightly over time, averages remained above 3.5 for the first 4 weeks before dipping in week 5 and recovering slightly in week 6.

<table>
<thead>
<tr>
<th>Week</th>
<th># of objectives</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>17</td>
<td>3.85</td>
<td>.717</td>
</tr>
<tr>
<td>Week 2</td>
<td>24</td>
<td>3.84</td>
<td>.580</td>
</tr>
<tr>
<td>Week 3</td>
<td>34</td>
<td>3.69</td>
<td>.831</td>
</tr>
<tr>
<td>Week 4</td>
<td>25</td>
<td>3.61</td>
<td>.672</td>
</tr>
<tr>
<td>Week 5</td>
<td>13</td>
<td>3.23</td>
<td>.799</td>
</tr>
<tr>
<td>Week 6</td>
<td>19</td>
<td>3.38</td>
<td>.724</td>
</tr>
</tbody>
</table>

Quality of Instruction – Students consistently indicated was of high quality with overall average responses of 4 or above in weeks 1 to 5 and just slightly lower (3.93) in week 6. Students believed that instructors demonstrated command of content knowledge, they were learning things useful for their other classes, and they were learning things helpful in preparing them for internships and their career. As weeks progressed, they did have a more difficult time keep up with the pace and indicated that they did not have as good an understanding of the materials as they did in the earlier weeks.

Professional Development - NACME provided professional development sessions in 5 of the first 6 weeks. Overall feedback was very positive, averaging above 4 each week. Students found these sessions to be well-organized and the presenters to be well-prepared and informed. They also indicated that they found these sessions of interest, they helped them think of additional PD opportunities, helped prepare for potential internships and motivated them to improve their preparation for a career in Engineering.
<table>
<thead>
<tr>
<th>Weekly Feedback</th>
<th>Week 1 - June 6-10 (n=51)</th>
<th>Week 2 - June 13-17 (n=39)</th>
<th>Week 3 - June 21-24 (n=53)</th>
<th>Week 4 - June 27- July 1 (n=44)</th>
<th>Week 5 - July 5 - 7 (n=48)</th>
<th>Week 6 - July 11 -15 (n=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.55</td>
<td>4.31</td>
<td>4.47</td>
<td>4.16</td>
<td>4.27</td>
<td>4.14</td>
</tr>
<tr>
<td>SD</td>
<td>.757</td>
<td>.694</td>
<td>.608</td>
<td>.776</td>
<td>.676</td>
<td>.751</td>
</tr>
<tr>
<td>The instructors demonstrated a command of the content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was interested and engaged in week’s classes</td>
<td>4.29</td>
<td>4.15</td>
<td>4.36</td>
<td>3.89</td>
<td>3.96</td>
<td>3.73</td>
</tr>
<tr>
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<td>.782</td>
<td>.779</td>
<td>.653</td>
<td>.895</td>
<td>.944</td>
<td>.962</td>
</tr>
<tr>
<td>I have a good understanding of what was addressed this week.</td>
<td>4.22</td>
<td>3.92</td>
<td>4.15</td>
<td>3.77</td>
<td>3.65</td>
<td>3.76</td>
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<tr>
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<td>.929</td>
<td>.770</td>
<td>.961</td>
<td>1.082</td>
<td>1.011</td>
</tr>
<tr>
<td>This week’s instruction and activities were well-organized</td>
<td>4.06</td>
<td>4.31</td>
<td>4.38</td>
<td>3.95</td>
<td>4.00</td>
<td>3.78</td>
</tr>
<tr>
<td>SD</td>
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<td>.832</td>
<td>.627</td>
<td>.806</td>
<td>.684</td>
<td>1.084</td>
</tr>
<tr>
<td>What I learned this week will help me in other classes I take.</td>
<td>4.57</td>
<td>4.26</td>
<td>4.36</td>
<td>4.09</td>
<td>4.08</td>
<td>3.89</td>
</tr>
<tr>
<td>SD</td>
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<td>.880</td>
<td>.682</td>
<td>.676</td>
<td>.821</td>
<td>.843</td>
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<tr>
<td>What I learned this week will be helpful in completing my degree.</td>
<td>4.51</td>
<td>4.26</td>
<td>4.42</td>
<td>4.05</td>
<td>3.94</td>
<td>3.86</td>
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<tr>
<td>SD</td>
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<td>.910</td>
<td>.719</td>
<td>.806</td>
<td>.909</td>
<td>.887</td>
</tr>
<tr>
<td>I will use what I learned this week to complete the course projects</td>
<td>4.59</td>
<td>4.38</td>
<td>4.55</td>
<td>4.41</td>
<td>4.25</td>
<td>4.08</td>
</tr>
<tr>
<td>SD</td>
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<td>.711</td>
<td>.637</td>
<td>.693</td>
<td>.758</td>
<td>.682</td>
</tr>
<tr>
<td>What I learned will better prepare me for potential internships.</td>
<td>4.51</td>
<td>4.36</td>
<td>4.58</td>
<td>4.30</td>
<td>4.25</td>
<td>4.19</td>
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<tr>
<td>SD</td>
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<td>.707</td>
<td>.570</td>
<td>.765</td>
<td>.838</td>
<td>.739</td>
</tr>
<tr>
<td>I was able to follow and keep up with the pace this past week</td>
<td>4.43</td>
<td>3.92</td>
<td>4.00</td>
<td>3.50</td>
<td>3.46</td>
<td>3.65</td>
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<tr>
<td>SD</td>
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<td>1.010</td>
<td>1.074</td>
<td>1.338</td>
<td>1.271</td>
<td>1.184</td>
</tr>
<tr>
<td>What I learned this week will be helpful in my future career</td>
<td>4.51</td>
<td>4.33</td>
<td>4.51</td>
<td>4.27</td>
<td>4.33</td>
<td>4.24</td>
</tr>
<tr>
<td>SD</td>
<td>.809</td>
<td>.737</td>
<td>.639</td>
<td>.694</td>
<td>.808</td>
<td>.723</td>
</tr>
<tr>
<td>Overall Means</td>
<td>4.42</td>
<td>4.22</td>
<td>4.38</td>
<td>4.04</td>
<td>4.02</td>
<td>3.93</td>
</tr>
<tr>
<td>SD</td>
<td>.646</td>
<td>.639</td>
<td>.496</td>
<td>.646</td>
<td>.669</td>
<td>.691</td>
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<tr>
<td>Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)</td>
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### NACME PD Feedback

<table>
<thead>
<tr>
<th>NACME PD Feedback</th>
<th>Week 1 - June 6 (n=51)</th>
<th>Week 2 - June 13 (n=39)</th>
<th>Week 3 - June 20 (n=53)</th>
<th>Week 4 - June 27 (no PD)</th>
<th>Week 5 - July 5 (n=48)</th>
<th>Week 6 - July 11 (n=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>This past week's NACME PD session was of great interest to me</td>
<td>4.12</td>
<td>.993</td>
<td>4.26</td>
<td>.795</td>
<td>4.21</td>
<td>.840</td>
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<tr>
<td>This week's PD helped me think about potential career opportunities</td>
<td>4.12</td>
<td>.973</td>
<td>4.18</td>
<td>.854</td>
<td>4.15</td>
<td>.841</td>
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<tr>
<td>This session will help me to explore other courses and PD opportunities.</td>
<td>4.20</td>
<td>.917</td>
<td>4.28</td>
<td>.724</td>
<td>4.08</td>
<td>.805</td>
</tr>
<tr>
<td>This will help me prepare for potential internship and other PD opportunities</td>
<td>4.37</td>
<td>.824</td>
<td>4.28</td>
<td>.686</td>
<td>4.23</td>
<td>.776</td>
</tr>
<tr>
<td>This week helped deepen my commitment to finishing my degree</td>
<td>4.10</td>
<td>1.06</td>
<td>3.90</td>
<td>.852</td>
<td>4.11</td>
<td>.870</td>
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<tr>
<td>This session helped motivate me for a successful career in engineering</td>
<td>4.31</td>
<td>.836</td>
<td>4.03</td>
<td>.873</td>
<td>4.09</td>
<td>.904</td>
</tr>
<tr>
<td>The presenter was well-prepared.</td>
<td>4.47</td>
<td>.784</td>
<td>4.49</td>
<td>.601</td>
<td>4.55</td>
<td>.667</td>
</tr>
<tr>
<td>The presenter was well-informed</td>
<td>4.57</td>
<td>.700</td>
<td>4.46</td>
<td>.643</td>
<td>4.43</td>
<td>.694</td>
</tr>
<tr>
<td>The presentation was well-organized</td>
<td>4.46</td>
<td>.706</td>
<td>4.41</td>
<td>.595</td>
<td>4.54</td>
<td>.699</td>
</tr>
<tr>
<td>My participation will improve my preparation for a career in Engineering</td>
<td>4.25</td>
<td>.891</td>
<td>4.23</td>
<td>.706</td>
<td>4.30</td>
<td>.696</td>
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<tr>
<td>I look forward to additional sessions like this.</td>
<td>4.31</td>
<td>.948</td>
<td>4.23</td>
<td>.742</td>
<td>4.45</td>
<td>.748</td>
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<tr>
<td>Overall Means</td>
<td>4.29</td>
<td>.734</td>
<td>4.24</td>
<td>.508</td>
<td>4.28</td>
<td>.619</td>
</tr>
</tbody>
</table>

Scale (1=SD, 2=D, 3=N, 4=A, 5=SA)
Weekly Feedback by Site

Comparisons among the three sites are summarized in the table below. Each week, statistically significant differences were found in relation to perceived knowledge and ability related to the weekly objectives week with students at the University of Arkansas reporting the most confidence. Also, in the later weeks (week 5 and 6), students at Arkansas reported significantly more positive weekly feedback in comparison to students at Morgan State. More specifically, students from Arkansas reported having a better understanding of what was addressed in weeks 5 and 6. Furthermore, students from Morgan State reported being significantly less engaged in class and had a harder time keeping up with the pace in week 6 in comparison to students from the other sites. Subsequent tables provide a comparison by site for specific weekly objectives.

<table>
<thead>
<tr>
<th>Week</th>
<th>Weekly Feedback</th>
<th>Arkansas</th>
<th>Mean (SD)</th>
<th>Kentucky</th>
<th>Mean (SD)</th>
<th>Morgan State</th>
<th>Mean (SD)</th>
<th>F</th>
<th>Site Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>16</td>
<td>4.39 (.53)</td>
<td>15</td>
<td>4.57 (.59)</td>
<td>20</td>
<td>4.34 (.78)</td>
<td>.584</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Objectives</td>
<td>16</td>
<td>4.09 (.58)</td>
<td>15</td>
<td>3.99 (.74)</td>
<td>20</td>
<td>3.53 (.71)</td>
<td>3.60*</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td></td>
<td>Prof. Dev.</td>
<td>16</td>
<td>4.32 (.53)</td>
<td>15</td>
<td>3.53 (.71)</td>
<td>20</td>
<td>4.34 (.94)</td>
<td>.269</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>12</td>
<td>4.38 (.44)</td>
<td>12</td>
<td>4.24 (.97)</td>
<td>15</td>
<td>4.08 (.61)</td>
<td>.598</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Objectives</td>
<td>12</td>
<td>4.06 (.62)</td>
<td>12</td>
<td>3.98 (.44)</td>
<td>15</td>
<td>3.55 (.56)</td>
<td>3.51*</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td></td>
<td>Prof. Dev.</td>
<td>12</td>
<td>4.17 (.53)</td>
<td>12</td>
<td>4.22 (.43)</td>
<td>15</td>
<td>4.32 (.56)</td>
<td>.275</td>
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<tr>
<td>3</td>
<td></td>
<td>15</td>
<td>4.37 (.55)</td>
<td>17</td>
<td>4.57 (.35)</td>
<td>21</td>
<td>4.22 (.52)</td>
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</tr>
<tr>
<td></td>
<td>Objectives</td>
<td>15</td>
<td>4.19 (.72)</td>
<td>17</td>
<td>3.93 (.62)</td>
<td>21</td>
<td>3.13 (.73)</td>
<td>11.56***</td>
<td>UA,UK &gt; MSU</td>
</tr>
<tr>
<td></td>
<td>Prof. Dev.</td>
<td>15</td>
<td>4.18 (.67)</td>
<td>17</td>
<td>3.13 (.73)</td>
<td>21</td>
<td>4.41 (.57)</td>
<td>.765</td>
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<td>4</td>
<td></td>
<td>15</td>
<td>4.18 (.62)</td>
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<td>Objectives</td>
<td>15</td>
<td>3.91 (.55)</td>
<td>14</td>
<td>3.91 (.56)</td>
<td>15</td>
<td>3.03 (.49)</td>
<td>13.51***</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
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<td>Prof. Dev.</td>
<td>15</td>
<td>NA</td>
<td>14</td>
<td>NA</td>
<td>15</td>
<td>NA</td>
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<td>5</td>
<td></td>
<td>15</td>
<td>4.13 (.65)</td>
<td>19</td>
<td>4.21 (.64)</td>
<td>14</td>
<td>3.64 (.60)</td>
<td>3.67*</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td></td>
<td>Objectives</td>
<td>15</td>
<td>3.58 (.51)</td>
<td>19</td>
<td>3.23 (1.02)</td>
<td>14</td>
<td>2.85 (.55)</td>
<td>3.30*</td>
<td>UA &gt; MSU</td>
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<tr>
<td></td>
<td>Prof. Dev.</td>
<td>15</td>
<td>4.25 (.60)</td>
<td>19</td>
<td>4.23 (.59)</td>
<td>14</td>
<td>3.99 (.74)</td>
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<td>6</td>
<td></td>
<td>16</td>
<td>4.24 (.69)</td>
<td>9</td>
<td>4.01 (.53)</td>
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<td>3.47 (.58)</td>
<td>5.40**</td>
<td>UA &gt; MSU</td>
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<td>16</td>
<td>3.71 (.58)</td>
<td>9</td>
<td>3.39 (.79)</td>
<td>12</td>
<td>2.93 (.65)</td>
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<td>UA &gt; MSU</td>
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<td>Prof. Dev.</td>
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<td>4.42 (.66)</td>
<td>9</td>
<td>4.05 (.76)</td>
<td>12</td>
<td>4.45 (.73)</td>
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*p<.05, **p<.01, ***p<.001
### Week 1 Objectives Comparison by Site

<table>
<thead>
<tr>
<th></th>
<th>Arkansas</th>
<th>Kentucky</th>
<th>Morgan State</th>
<th>Sig. Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Using Python, create, use, and troubleshoot variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.00</td>
<td>4.40</td>
<td>3.55</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>.816</td>
<td>.737</td>
<td>.887</td>
<td></td>
</tr>
<tr>
<td><strong>Read and write Python statements, expressions, conditionals, loops and functions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>15</td>
<td>20</td>
<td></td>
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<tr>
<td>Mean</td>
<td>4.00</td>
<td>4.33</td>
<td>3.65</td>
<td></td>
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<tr>
<td>SD</td>
<td>.816</td>
<td>.724</td>
<td>.813</td>
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<tr>
<td><strong>Build a basic Python object</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.25</td>
<td>4.27</td>
<td>3.65</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>.683</td>
<td>.799</td>
<td>.875</td>
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<tr>
<td><strong>Build a hierarchy of objects</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3.94</td>
<td>3.73</td>
<td>3.55</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>.929</td>
<td>.961</td>
<td>.945</td>
<td></td>
</tr>
<tr>
<td><strong>Distinguish procedural from object-oriented programming</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
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<td><strong>Interpret different types of exceptions</strong></td>
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### Week 1 Objectives

#### Comparison by Site

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<th>Sig. Differences</th>
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(Continued on Page 55)

### Week 2 Objectives

#### Comparisons by site

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<td>Create, analyze and modify a Pandas Series</td>
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### Week 2 Objectives

#### Comparisons by site

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<td>Sort data contained in Pandas DataFrames</td>
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<tr>
<td>Create and interpret charts and plots to visualize data</td>
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<td>Determine which visualization is appro for a dataset</td>
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<td>Create charts with Matplotlib</td>
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<td>Create charts with seaborn</td>
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<td>Upload data to Colab</td>
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<td>Download data from public URLs</td>
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<td>Download and obtain data from Kaggle</td>
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<td>Unzip compressed data</td>
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<td>Identify and calculate statistics for a DataFrame</td>
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<td>Analyze data across DataFrame objects</td>
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<td>Select appropriate visualizations to use in analysis</td>
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<tr>
<td>Interpret visualizations to answer questions about a dataset</td>
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<tr>
<td>Identify and fill in missing data points in a dataset</td>
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<td>12</td>
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<tr>
<td>Identify and correct broken data points in a dataset</td>
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<td>Acquire and load dataset(s) into Pandas structures</td>
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<tr>
<td>Inspect data columns descriptions and statistics</td>
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<tr>
<td>Explore data to understand relationship between features</td>
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<tr>
<td>Use visualizations to convey trends</td>
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<td>Confidence Scale (1=not at all, 5=A great extent)</td>
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### Week 3 Objectives - comparisons by site

<table>
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<th>Mean</th>
<th>SD</th>
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<td>Load data packaged with scikit-learn</td>
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<td>Generate sample data using scikit-learn</td>
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<td>Train a sample model and make predictions using that model</td>
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<td>Create metrics around model performance</td>
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<td>Visualize predictions returned from a model</td>
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<td>Train a linear regression model using real data</td>
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(Continued on Page 57)
### Use Root Mean Square Error (RMSE) to evaluate a linear regression model

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### Visualize features, targets, and predicted targets using a scatter plot

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<th>Morgan State</th>
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### Extract quantitative measurements of a regression’s model

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### Make qualitative judgements of a regression model’s predictions

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### Apply polynomial models to regression problems

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### Recognize and correct model overfitting

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### Distinguish between types on tensors (scalers, vectors, matrices, cubes, etc.)

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### Identify key differences between TensorFlow 1 and TensorFlow 2

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### Perform basic linear algebra operations on tensors using TensorFlow

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### Convert tensors to NumPy arrays and Python lists

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### Use TensorFlow Estimator API to build a model

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<th>Morgan State</th>
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### Adjust model hyperparameters

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## Week 3 Objectives

Comparison by Site

<table>
<thead>
<tr>
<th>Objective</th>
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<th>Importance</th>
<th>Confidence</th>
<th>Feedback</th>
<th>Notes</th>
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<td>Use TensorFlow/Keras API to build a deep neural network</td>
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<td>Understand the implications of activation function choice</td>
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<td>Argue the merits (or lack thereof) for a regression model</td>
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<td>1.03</td>
<td>17</td>
<td>3.76</td>
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<td>Discuss the ethics of a regression model</td>
<td>15</td>
<td>4.40</td>
<td>.737</td>
<td>17</td>
<td>4.12</td>
</tr>
<tr>
<td>Explore a dataset with minimal guidance</td>
<td>15</td>
<td>4.07</td>
<td>.961</td>
<td>17</td>
<td>4.18</td>
</tr>
<tr>
<td>Build a regression model and perform hyperparameter tuning</td>
<td>15</td>
<td>4.27</td>
<td>.704</td>
<td>17</td>
<td>4.00</td>
</tr>
<tr>
<td>Judge the quality of a regression model</td>
<td>15</td>
<td>4.33</td>
<td>.724</td>
<td>16</td>
<td>3.94</td>
</tr>
</tbody>
</table>
### Week 4 Objectives – Comparison by Site

<table>
<thead>
<tr>
<th>Objective</th>
<th>University of Arkansas</th>
<th>University of Kentucky</th>
<th>Morgan State University</th>
<th>Sig. Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differentiate between classification and regression</td>
<td>15 4.13 .743</td>
<td>14 4.07 .917</td>
<td>15 3.27 .704</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Interpret accuracy, precision, recall, and F1 scoring to classification models</td>
<td>15 4.27 .799</td>
<td>14 3.71 .825</td>
<td>15 3.33 .900</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td>Create a logistic regression model for a binary classification</td>
<td>15 3.87 .640</td>
<td>14 4.07 .616</td>
<td>15 3.13 .640</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Interpret a confusion matrix for a binary classification model</td>
<td>15 3.73 .884</td>
<td>14 3.64 1.082</td>
<td>15 3.13 .834</td>
<td>NA</td>
</tr>
<tr>
<td>Use grid search to find optimal hyperparameters for a model</td>
<td>15 4.00 .655</td>
<td>14 3.93 .829</td>
<td>15 2.93 .884</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Build a classification model for data with more than two classes</td>
<td>15 3.93 .799</td>
<td>14 4.00 .679</td>
<td>15 3.07 .884</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Use cross-validation to evaluate a model</td>
<td>15 3.93 .704</td>
<td>14 3.93 .616</td>
<td>15 2.93 .799</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Create a model pipeline for training and predicting</td>
<td>15 3.87 .640</td>
<td>14 3.86 .770</td>
<td>15 2.93 .704</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Design, build, train and evaluate a Linear Classifier model in TensorFlow</td>
<td>15 3.93 .704</td>
<td>14 3.93 .616</td>
<td>15 2.93 .884</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Submit predictions to a Kaggle challenge</td>
<td>15 4.47 .743</td>
<td>13 4.23 1.013</td>
<td>15 3.13 .834</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Use effective strategies for feature reduction in image classification</td>
<td>15 3.93 .594</td>
<td>14 3.71 .825</td>
<td>15 2.93 .799</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Perform multiclass image classification using a deep neural network</td>
<td>15 3.87 .743</td>
<td>14 3.71 .914</td>
<td>15 2.93 .884</td>
<td>UA &gt; MSU</td>
</tr>
</tbody>
</table>
## Week 4 Objectives

### Comparison by Site

<table>
<thead>
<tr>
<th>Objective</th>
<th>State 1</th>
<th>Mean</th>
<th>SD</th>
<th>State 2</th>
<th>Mean</th>
<th>SD</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevent overfitting using early stopping and dropout</td>
<td>15</td>
<td>4.27</td>
<td>.799</td>
<td>14</td>
<td>4.00</td>
<td>.784</td>
<td>15, .884</td>
</tr>
<tr>
<td>Resize, pad and change the orientation of an image</td>
<td>15</td>
<td>4.00</td>
<td>.845</td>
<td>14</td>
<td>4.07</td>
<td>.730</td>
<td>15, .756</td>
</tr>
<tr>
<td>Load and image with OpenCV</td>
<td>15</td>
<td>4.27</td>
<td>.594</td>
<td>14</td>
<td>4.07</td>
<td>.829</td>
<td>15, .743</td>
</tr>
<tr>
<td>Modify an image</td>
<td>14</td>
<td>3.93</td>
<td>.829</td>
<td>14</td>
<td>4.07</td>
<td>.730</td>
<td>15, .704</td>
</tr>
<tr>
<td>Change the color encoding of an image</td>
<td>14</td>
<td>3.57</td>
<td>.938</td>
<td>14</td>
<td>4.00</td>
<td>.679</td>
<td>15, .743</td>
</tr>
<tr>
<td>Implement the process to save the state of a model</td>
<td>14</td>
<td>3.79</td>
<td>.893</td>
<td>14</td>
<td>3.86</td>
<td>.864</td>
<td>15, .594</td>
</tr>
<tr>
<td>Revise and use a persisted model</td>
<td>15</td>
<td>3.87</td>
<td>.915</td>
<td>14</td>
<td>3.64</td>
<td>1.082</td>
<td>15, .594</td>
</tr>
<tr>
<td>Use OpenCV to process images and video</td>
<td>15</td>
<td>3.60</td>
<td>.737</td>
<td>14</td>
<td>4.14</td>
<td>.770</td>
<td>15, .704</td>
</tr>
<tr>
<td>Use a pre-trained model to identify and label objects in each frame of a video</td>
<td>15</td>
<td>3.67</td>
<td>.900</td>
<td>14</td>
<td>4.00</td>
<td>.877</td>
<td>15, .770</td>
</tr>
<tr>
<td>Judge the classification quality and when to apply predicted labels</td>
<td>15</td>
<td>3.67</td>
<td>.900</td>
<td>14</td>
<td>3.93</td>
<td>.616</td>
<td>15, .561</td>
</tr>
<tr>
<td>Identify examples of classification models that had unintended, harmful effects</td>
<td>15</td>
<td>3.60</td>
<td>.737</td>
<td>14</td>
<td>3.93</td>
<td>.917</td>
<td>15, .834</td>
</tr>
<tr>
<td>Distinguish potential causes of bias and harmful errors in classification</td>
<td>15</td>
<td>3.73</td>
<td>.799</td>
<td>14</td>
<td>3.50</td>
<td>1.225</td>
<td>15, .756</td>
</tr>
<tr>
<td>Discuss ways to mitigate bias</td>
<td>15</td>
<td>3.87</td>
<td>.834</td>
<td>14</td>
<td>3.57</td>
<td>1.399</td>
<td>15, .845</td>
</tr>
</tbody>
</table>
### Week 5 Objectives Comparison by Site

<table>
<thead>
<tr>
<th>Objective</th>
<th>University of Arkansas</th>
<th>University of Kentucky</th>
<th>Morgan State University</th>
<th>Sig. Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the components of a CNN</td>
<td>15 3.80 (0.561)</td>
<td>19 3.53 (1.219)</td>
<td>14 2.57 (0.646)</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Identify the effect of different filters</td>
<td>15 3.53 (0.834)</td>
<td>19 3.47 (1.264)</td>
<td>14 3.00 (0.679)</td>
<td></td>
</tr>
<tr>
<td>Use TensorFlow to build a recurrent neural network</td>
<td>15 3.87 (0.743)</td>
<td>19 3.58 (1.017)</td>
<td>14 2.71 (0.611)</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Feed time series data to a neural network to make sequence predictions</td>
<td>15 3.27 (0.799)</td>
<td>19 3.53 (1.073)</td>
<td>14 2.93 (0.829)</td>
<td></td>
</tr>
<tr>
<td>Use text processing and feature extraction tools</td>
<td>15 3.40 (0.828)</td>
<td>19 3.21 (1.182)</td>
<td>14 2.93 (0.917)</td>
<td></td>
</tr>
<tr>
<td>Train NLP models using bag-of-words and sequential representations</td>
<td>15 3.60 (0.910)</td>
<td>19 3.26 (1.147)</td>
<td>13 2.62 (0.870)</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td>Understand the fundamental structure of autoencoders</td>
<td>15 3.47 (0.640)</td>
<td>19 3.16 (1.463)</td>
<td>14 2.86 (0.663)</td>
<td></td>
</tr>
<tr>
<td>Implement an autoencoder for compressing and denoising images</td>
<td>15 3.73 (0.594)</td>
<td>19 3.00 (1.528)</td>
<td>14 3.00 (0.679)</td>
<td></td>
</tr>
<tr>
<td>Combine multiple models using a wrapper model</td>
<td>15 3.53 (0.834)</td>
<td>18 3.11 (1.323)</td>
<td>14 2.79 (0.699)</td>
<td></td>
</tr>
<tr>
<td>Familiarity with the PyTorch API</td>
<td>15 3.33 (0.816)</td>
<td>19 2.63 (1.461)</td>
<td>14 2.57 (0.852)</td>
<td></td>
</tr>
<tr>
<td>Employ the fastai API to implement a CNN</td>
<td>15 3.53 (0.990)</td>
<td>19 2.74 (1.327)</td>
<td>14 2.57 (0.852)</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td>Discuss ethical implications of a model that involves medical decisions</td>
<td>15 3.87 (0.915)</td>
<td>19 3.53 (1.307)</td>
<td>14 3.43 (0.938)</td>
<td></td>
</tr>
<tr>
<td>Create a classification model end-to-end, including parameter tuning and final validation</td>
<td>15 3.60 (0.632)</td>
<td>19 3.26 (1.147)</td>
<td>14 3.07 (0.829)</td>
<td></td>
</tr>
</tbody>
</table>
### Week 6 Objectives Comparison by Site

<table>
<thead>
<tr>
<th>Objective</th>
<th>University of Arkansas</th>
<th>Kentucky</th>
<th>Morgan State</th>
<th>Sig. Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differentiate clustering from regression classification</td>
<td>16 3.75 .683</td>
<td>9 3.44 1.333</td>
<td>12 2.83 .577</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td>Manually cluster objects using a tactic similar to the k-means algorithm</td>
<td>16 3.75 .683</td>
<td>9 3.89 .782</td>
<td>12 3.00 .739</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Identify the difference between supervised and unsupervised learning</td>
<td>16 4.06 .772</td>
<td>9 3.67 1.118</td>
<td>12 3.33 .888</td>
<td></td>
</tr>
<tr>
<td>Create a k-means model</td>
<td>16 3.81 .750</td>
<td>9 3.67 1.225</td>
<td>12 3.25 .622</td>
<td></td>
</tr>
<tr>
<td>Interpret the output of a k-means model</td>
<td>16 3.75 .856</td>
<td>9 3.78 .972</td>
<td>12 3.17 .577</td>
<td></td>
</tr>
<tr>
<td>Describe embeddings, why they are used, and how they are trained</td>
<td>16 3.87 .806</td>
<td>9 3.22 1.202</td>
<td>12 3.08 .669</td>
<td></td>
</tr>
<tr>
<td>Implement embedding in practice</td>
<td>16 3.75 .775</td>
<td>9 3.33 1.118</td>
<td>12 3.00 .739</td>
<td></td>
</tr>
<tr>
<td>Create and apply a decision tree algorithm for classification</td>
<td>16 3.75 .775</td>
<td>9 4.00 .866</td>
<td>12 3.08 .669</td>
<td>UK &gt; MSU</td>
</tr>
<tr>
<td>Perform ensemble learning using random forests</td>
<td>16 3.75 .856</td>
<td>9 3.89 .782</td>
<td>12 3.08 .793</td>
<td></td>
</tr>
<tr>
<td>Apply limits to depth and split size to reduce overfitting</td>
<td>15 3.93 .799</td>
<td>9 4.00 .707</td>
<td>12 2.92 .793</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Describe the basic concept of KNN</td>
<td>15 3.80 .775</td>
<td>9 4.00 1.323</td>
<td>12 2.83 .835</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td>Use KNN to solve a classification problem</td>
<td>15 3.80 .775</td>
<td>9 3.89 1.054</td>
<td>12 2.75 .754</td>
<td>UA, UK &gt; MSU</td>
</tr>
<tr>
<td>Identify and describe the components of Bayes' Theorem</td>
<td>16 3.63 .957</td>
<td>9 3.33 1.118</td>
<td>12 2.75 1.055</td>
<td></td>
</tr>
<tr>
<td>Predict spam or ham using Bayes</td>
<td>15 3.27 .704</td>
<td>9 2.78 1.787</td>
<td>12 2.75 1.055</td>
<td></td>
</tr>
<tr>
<td>Predict review sentiment (+ or -) using Bayes</td>
<td>16 3.44 .629</td>
<td>9 2.22 1.302</td>
<td>12 2.75 1.055</td>
<td></td>
</tr>
<tr>
<td>Define problems for which support vector machines are a good fit</td>
<td>16 3.69 .873</td>
<td>9 2.78 1.394</td>
<td>12 2.83 .937</td>
<td></td>
</tr>
<tr>
<td>Understand the primary settings used to tune a support vector machine and their tradeoffs</td>
<td>16 3.44 .629</td>
<td>9 3.00 1.500</td>
<td>12 2.75 .866</td>
<td></td>
</tr>
<tr>
<td>Understand the idea of gradient boosting</td>
<td>16 3.75 .775</td>
<td>9 3.33 1.500</td>
<td>11 2.64 .809</td>
<td>UA &gt; MSU</td>
</tr>
<tr>
<td>Implement the XGBoost algorithm</td>
<td>16 3.50 .730</td>
<td>9 2.22 1.093</td>
<td>12 2.75 .866</td>
<td>UA &gt; MSU</td>
</tr>
</tbody>
</table>
Recommendations
Consider course prerequisites– Students described challenges in learning programming and were limited in other background skills to do the work in a timely manner. They specifically indicated that having more experience with programming, statistics and linear Algebra would be beneficial.

Course Organization and Expectations – Student focus group comments and ongoing feedback described challenges they had navigating through the course materials and assignments. Students from each site described that course expectations and details related to required assignments could be more clearly communicated. They suggested an orientation to the class and syllabus so students understand what is expected. They also suggested using a learning management system (LMS) to organize course activities, materials and assignments. There are helpful organizational features within these LMS such as a dashboard that alert participants (students, TAs and instructors) of the course schedule and when upcoming assignments are due. LMS also offer a way to organize course materials and store completed assignments and feedback that might be helpful to review when working on subsequent tasks.

Course Pace and Modifications -The existing curriculum serves as a guide but some modifications could be made to better serve all students. Two items, focused on student ability to keep up with the pace and have a good understanding what was addressed in class, received the lowest average responses each week. This was especially true as the course progressed and the content became more challenging. Within the course, provide students with opportunities to practice and get feedback or remedial resources to review and develop the skills they may not have had prior to the course. In the focus groups, students also indicated that having some time or days built into the course schedule to catch up and get additional help from TAs or faculty would be valuable.

References


The Student Attitudes Toward STEM Survey (S-STEM) (Friday Institute for Educational Intervention, 2012; Unfried, Faber, Stanhope, & Wiebe, 2015)