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Intro to Mechanical Engineering: A New Course To Improve Major Trajectory

Dr. Ahmed Ali HASAN, University of New Mexico

Dr. Hasan taught many undergraduate classes in Mechanical Engineering, Nuclear Engineering and Chemical & Biological Engineering at the University of New Mexico. He has research experience in the interaction of inorganic contaminants with mineral surfaces, colloidal transport of radioactive and metal contaminants and their applications to remediation, physicochemical characterization of soil and mineral surfaces, and radionuclide migration. Past research has included the investigation of some radionuclides of environmental interests with different types of soils and rocks. Research interests included Low- and high-level radioactive waste disposal, conditioning of radioactive waste, radiation protection, and subsurface contaminant transport. Other research program includes hazardous and mixed waste; performance assessment of the high-level radioactive waste repositories; colloidal transport of contaminants and; disposal of Greater-than-Class C radioactive waste. His research area of Contaminant Transport encompassed the physics and chemistry of the fate and transport of contaminants in aquifers. He has accumulated laboratory experience in purchasing, installing, and operating analytical equipment including colloid characterization equipment. Recent experience includes Integrated Management of Radioactive Sealed Sources (IMPRSS); a Cradle-to-Grave management of radioactive sources ensures the safety and security of sources during its life cycle. Experienced in many technical issues related to safety and security of radioactive sealed sources. Current experience also is related to developing an Integrated Model for Sustainable Development (IMSD), an innovative approach that addresses the energy-water-environment nexus. He supervised more than 55 international fellows who received their training in many areas such as disposal of low- and high-level radioactive waste, decommissioning and decontamination, and water and wastewater treatment.

Prof. Tariq Khraishi, University of New Mexico

Khraishi currently serves as a Professor of Mechanical Engineering at the University of New Mexico. His general research interests are in theoretical, computational and experimental solid mechanics and materials science. He has taught classes in Dynamics, Materials Science, Advanced Mechanics of Materials, Elasticity and Numerical Methods. For many years now, he has engaged himself in the scholarship of teaching and learning, and published several papers in the engineering education field.

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Intro to Mechanical Engineering: A New Course to Improve Major Trajectory

Ahmed Hasan, Tariq Khraishi
Mechanical Engineering Department
University of New Mexico

Abstract

The paper is centered around the activities of a newly developed introductory course to mechanical engineering at the University of New Mexico (UNM). The course offers hands-on activities as well as exposure to modern mechanical engineering fields and applications. The math and science behind the activities and the modern concepts/fields are described. The paper describes the structure of the course and the motivation behind it. Also provided are data on student participation and engagement, plus comparison to institutional retention data. The results of this work show overall promise for this new course, but longer-term data are needed for ascertainment.

Introduction:

The Mechanical Engineering (ME) Department at the School of Engineering (SOE), University of New Mexico (UNM), started to offer a new class (ME150) in the Spring of 2019 titled "An Introduction of Modern Mechanical Engineering". The class aims to offer hands-on activities and projects on modern applications of mechanical engineering, while describing the science and math behind them. The objective of this course is to introduce engineering freshman students to the various applications of the mechanical engineering profession. By the time students complete this course, they should be able to:

- describe mechanical engineering fields and related activities such as Energy, Engineering Materials, Biomedical Engineering, Mechatronics, Computational design, 3D Printing, Propulsion and Engine Systems, and Advanced tribology
- understand some of the subfields of mechanical engineering (HVAC, thermal fluids, solid mechanics, material science, biomechanics, controls, dynamics and vibrations, and manufacturing)
- distinguish mechanical engineering from other types of engineering.
- demonstrate mechanical engineering design and management.
- utilize engineering measurements and tools, units, and conversions.
- perform data analysis and graphical display of information.
- describe the different types of forces, motion and machine components.
- demonstrate understanding of various types of mechanical energy and the nexus between energy-water-environment.

The class aims to engage pre-major and freshmen students in learning activities related to engineering careers, while they are taking other pre-engineering classes for the first couple of years in their college[1]. This engagement became even more important due to lower college enrollment driven by population demographic changes and due to the negative impact of the COVID-19 pandemic. Engineering schools play important role in supplying the necessary talents that serve the local private, state and federal businesses[2,3]. Other universities utilize an introductory course in their curriculum, similar to ME150, in order to improve retention and preparation for their bachelor degree[4,5,6,7,8,9].

The University of New Mexico (UNM) is located in the central region of the State of New Mexico which is host to several national laboratories such as Sandia National Laboratories, Los Alamos National Laboratory, and Air Force Research Laboratory. Such laboratories attract engineering students and constitute strong competition for several other state, manufacturing and processing industrial complexes. Therefore, the SOE must create new ways to recruit new students and increase retention of existing students[10,11].

The class hands-on activities represent 80% of the class time spent in conducting experiments and research using experimental kits to learn about machine learning and control, Newton's three laws of motion, advanced tribology, propulsion and engines, and bioengineering. This paper provides an update to tables that are developed to gage the success of ME150 in retaining students in the engineering program, especially in mechanical engineering.

In a previous study by the first author, a skill gap analysis for the advanced manufacturing workforce in the state of New Mexico concluded that UNM and Central New Mexico Community College (CNM) and their respective remote branches produce 66.41% of the total annual awarded degrees related to the advanced manufacturing industry. The skill gap analysis projected an annual gap of 459 occupancies among engineering occupations needed for advanced manufacturing in the state for the next 10 years, which predict that hiring and retaining qualified candidates in advanced manufacturing will be a major challenge for the local economy[12].

Class Activities:

Students were able to successfully complete various experiments, collect data, and present in the class. Students conducted various hands-on experiments working on a bench-scale robotic arm to conduct machine learning programming as well as use it for laser engravement, plotting, 3D printing (Figure 1-5), which are all components of manufacturing automation.

Figure 1. 3D Printing with Dobot's Robotic Arm

Figure 2. Students work on machine learning with Dobot's Robotic Arm

Students learn about advanced tribology by conducting 3D laser scans for several objects and spare parts using a bench-top laser scanner where they create STL images that are usable in any commercial 3D printer (Figure 6).

Figure 3. Use of Robotic Arm in Car Engine Plotting

Figure 4. Demo of Using Robotic Arm for Line Packaging

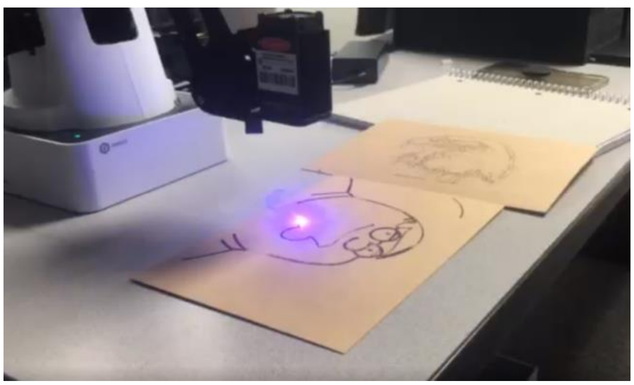


Figure 5. Robotic arm laser engraving

Figure 6. 3D Laser Scanning of an object

Students were able to demonstrate what they learned from the robotic experiments by performing supervised assisted welding trials when visiting the fuse maker space at Central New Mexico (CNM) Community College. Students conducted bench-scale experiments to learn about mechanical and static forces by building different bridge designs and comparing the calculated forces versus the measured ones (Figures 7 & 8). They conducted time-of-flight experiment to build their knowledge of aerospace applications by predicting a projectile height, speed, time and landing site. Students learned about renewable energy by using an experimental kit that helped them study the effects of wind speed and light intensity on electrical production.

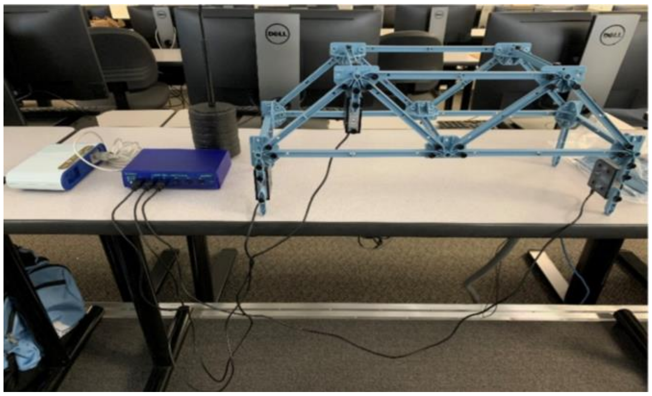


Figure 7. Students worked on a bridge experiment

Figure 8. Bridge Equilibrium Forces

Student Surveys:

A nine-question anonymous survey was distributed to the students to reflect on the success and effectiveness of the course and identify areas for improvement. The collective results from 29 students surveyed in 2019 and 2020 are displayed in Figures 9-17.

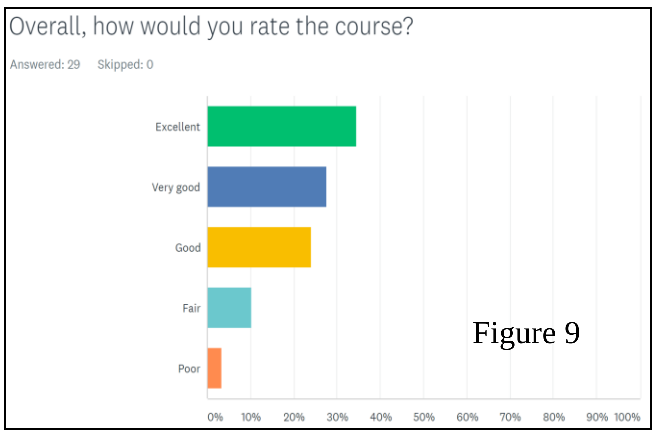


Figure 9

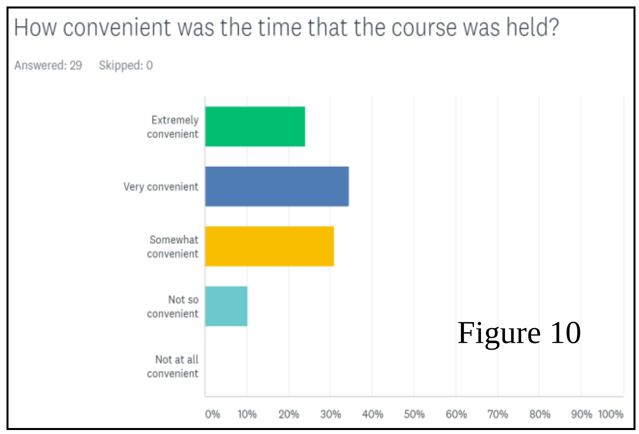


Figure 10

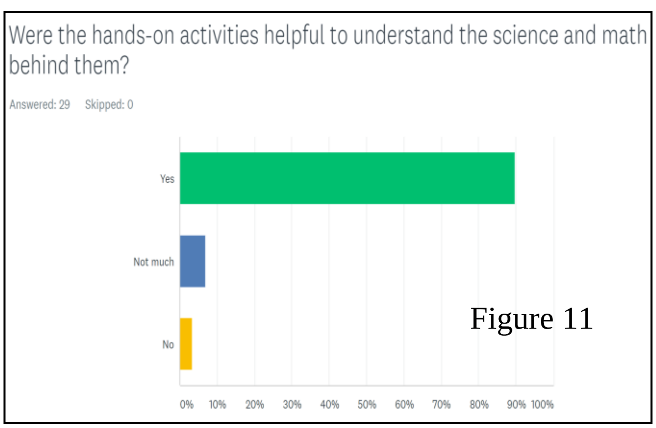


Figure 11

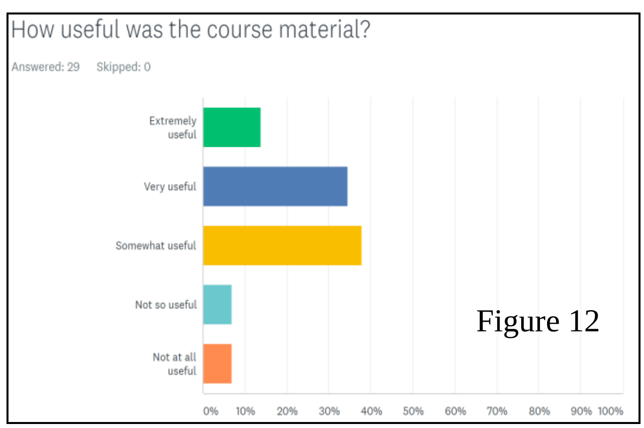


Figure 12

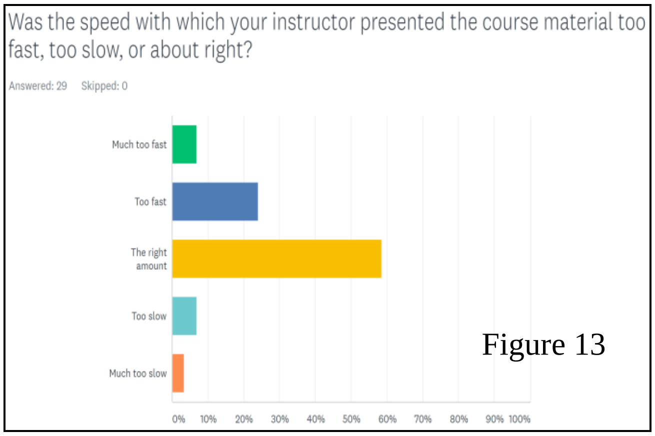


Figure 13

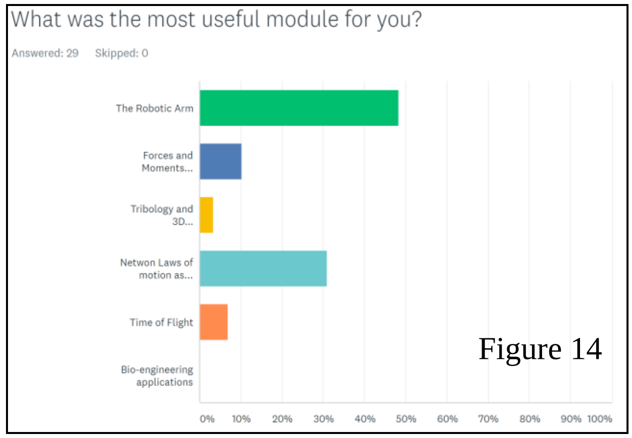


Figure 14

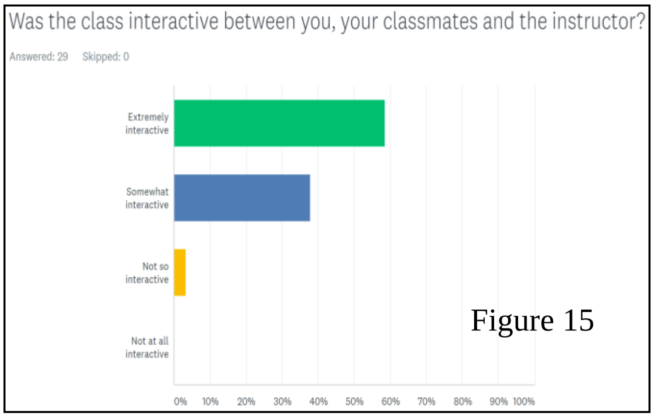


Figure 15

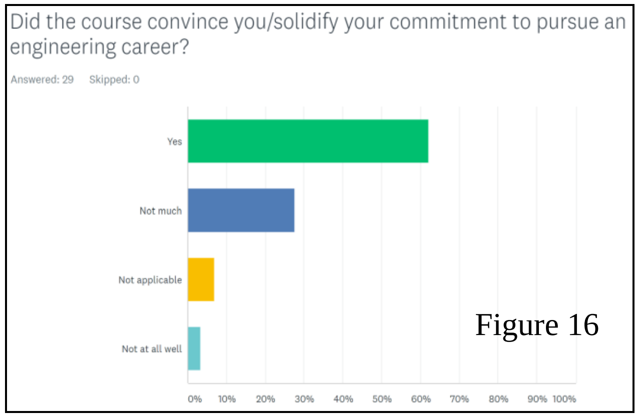


Figure 16

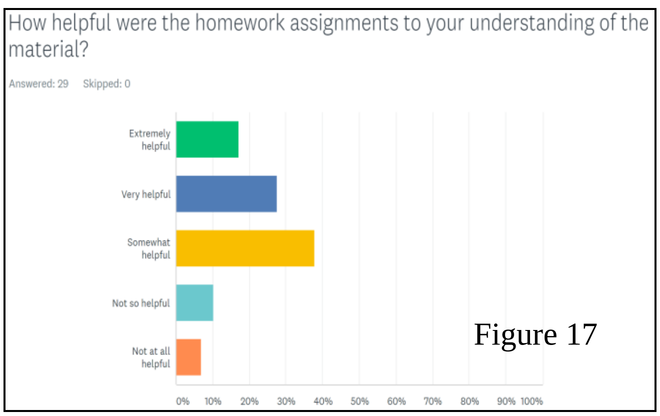
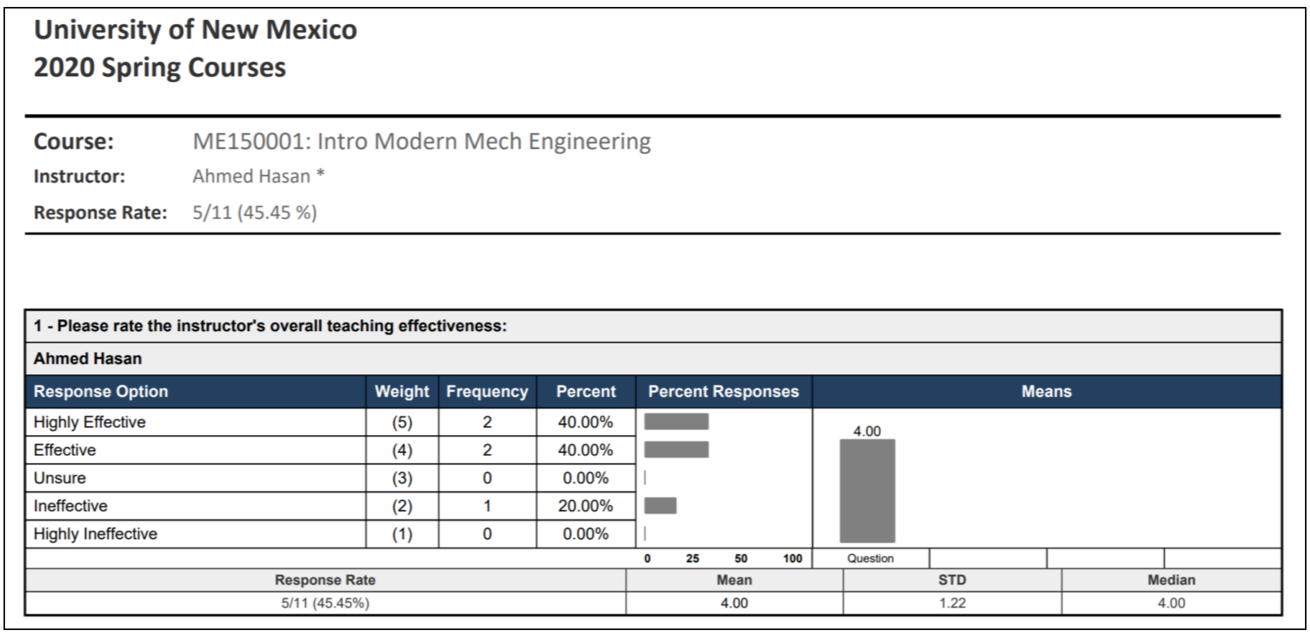


Figure 17

Figure 9 shows that 88% of the students rated the course as good, very good or excellent. When asked about how convenient the time for the class was, only 10% did not like the class timing (Figure 10). Figure 11 shows that 90% of the students agreed that the hands-on activities were helpful to understand the math and science behind them (note that the class is designed to offer math and physics that is followed by hands-on activities). In Figure 12, it shows that 88% of the students found the course material helpful to some extent. Regarding the pace of material presentation in the course, 58%, of the students said that the instructor speed was just fine. See Figure 13. The instructor believes that the diversity in answers to this question reflects the diversity of student backgrounds, including technical strength, coming from various high schools in the State of New Mexico. Figure 14 shows that 59% of the students found that the robotic arm was the most useful module of the course. Also, 30% chose the experiments related to Newton's laws of motion as the most useful one. The remaining were divided between the tribology 3D scanning (4%) and the time of flight (7%) experiments. One of the main goals of the ME150 is to teach team skills and communication. Figure 15 shows that overwhelmingly 98% of the students agreed that the class was interactive (39% saying it was somewhat interactive whereas 59% said that it was extremely interactive). ME150 was developed to increase students' retention in the ME department. Therefore, when asked about if the course helped them solidify their commitment to pursuing an engineering career (Figure 16), 62% responded "Yes". There were some who answered, "Not applicable" (7%) since they were not engineering majors when they filled-out the survey. The 28% who responded "Not much" might by indicating their prior commitment to their engineering program (e.g. some students were not freshmen when they took this course). Finally, when the survey questioned the students about the effectiveness of the homework assignments (Figure 17), 84% concurred to varying extents that it was indeed helpful.

The students' evaluations of the course for Spring 2020 and Fall of 2020 are presented in Figures 18 and 19, respectively. In Spring 2020, students rated the instructor with a mean of 4.00/5.00 (80%), while in Fall 2020 they rated him with a mean of 4.36/5.00 (87.2%). These results are consistent with the course survey result shown in Figure 9.



University of New Mexico
2020 Spring Courses

Course: ME150001: Intro Modern Mech Engineering
Instructor: Ahmed Hasan *
Response Rate: 5/11 (45.45 %)

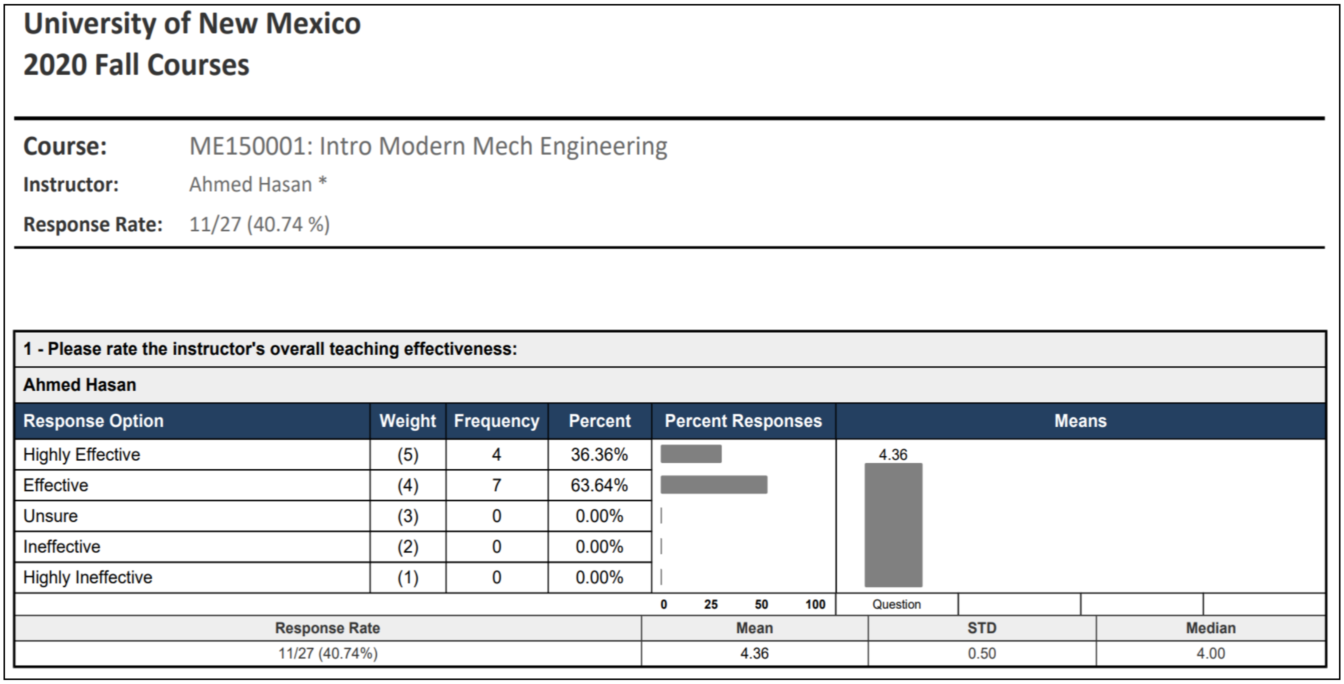
1 - Please rate the instructor's overall teaching effectiveness:

Ahmed Hasan

Response Option	Weight	Frequency	Percent
Highly Effective	(5)	2	40.00%
Effective	(4)	2	40.00%
Unsure	(3)	0	0.00%
Ineffective	(2)	1	20.00%
Highly Ineffective	(1)	0	0.00%

Response Rate	Mean	STD	Median
5/11 (45.45%)	4.00	1.22	4.00

Figure 18. Students' course evaluation for Spring 2020.



University of New Mexico
2020 Fall Courses

Course: ME150001: Intro Modern Mech Engineering
Instructor: Ahmed Hasan *
Response Rate: 11/27 (40.74 %)

1 - Please rate the instructor's overall teaching effectiveness:

Ahmed Hasan

Response Option	Weight	Frequency	Percent
Highly Effective	(5)	4	36.36%
Effective	(4)	7	63.64%
Unsure	(3)	0	0.00%
Ineffective	(2)	0	0.00%
Highly Ineffective	(1)	0	0.00%

Response Rate	Mean	STD	Median
11/27 (40.74%)	4.36	0.50	4.00

Figure 19. Students' course evaluation for Fall 2020.

Since a main reason for the establishment of ME150 is to help with freshman or pre-major students' retention, three tables (Tables 1, 2 and 3) are presented for this purpose. The tables are meant to gage the success of ME150 in retaining students in the engineering program, especially mechanical engineering. Tables 1, 2 and 3 show the list of ME150 students enrolled in three different semesters, Spring 2019, Fall of 2019 and Spring 2020. The second or third columns of the table are consecutive semesters with indication of that semester's enrollment status. In other words, the tables show students who continued their enrollment in the mechanical engineering program.

Table 1. ME150 Students Retention in Engineering Program – Spring 2019

Stu. #	Spring 2019	Fall 2019	Fall 2020
1	Mechanical Engineering	Mechanical Engineering	Mechanical Engineering
2	Mechanical Engineering	Mechanical Engineering	Mechanical Engineering
3	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
4	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
5	Pre Mechanical Engineering	Pre-Mechanical Engineering	Business Admin
6	Pre Mechanical Engineering	Pre-Mechanical Engineering	Mechanical Engineering
7	Mechanical Engineering	Mechanical Engineering	Mechanical Engineering
8	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
9	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre- Business Admin
10	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
11	Pre Mechanical Engineering	Pre-Mechanical Engineering	Mechanical Engineering

12	Pre Chemical Engineering	Pre-Chemical Engineering	Pre-Chemical Engineering
13	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
14	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering

Table 2. ME150 Students Retention in Engineering Program – Fall 2019

Stu. #	Fall 2019	Spring 2020	Fall 2020
1	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
2	Pre Mechanical Engineering	Pre-Mechanical Engineering	Bachelor of Arts
3	Pre Mechanical Engineering	Pre-Mechanical Engineering	BA in Architecture
4	Undecided	Pre-Computer Science	Pre-Computer Science
5	Pre Mechanical Engineering	Pre-Mechanical Engineering	Bachelor of Arts
6	Pre Business Administration	Pre-Business Administration	Bachelor of Business Admin
7	Undecided	Undecided	Pre-Mechanical Engineering
8	Mechanical Engineering	Mechanical Engineering	Mechanical Engineering
9	Non-Degree	Non-Degree	Pre-Mechanical Engineering
10	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
11	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
12	Mechanical Engineering	Mechanical Engineering	Mechanical Engineering
13	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering
14	Pre Mechanical Engineering	Mechanical Engineering	Mechanical Engineering
15	Pre Mechanical Engineering	Pre-Mechanical Engineering	Pre-Mechanical Engineering

Table 3. ME150 Students Retention in Engineering Program – Spring 2020

Stu. #	Spring 2020	Fall 2020
1	Pre Mechanical Engineering	Pre Art
2	Pre Mechanical Engineering	Pre-Mechanical Engineering
3	Pre Political Science	Pre-Political Science
4	Pre Mechanical Engineering	Pre-Mechanical Engineering
5	Pre Mechanical Engineering	Pre-Mechanical Engineering
6	Pre Mechanical Engineering	Pre-Mechanical Engineering
7	Pre Mechanical Engineering	Pre-Mechanical Engineering
8	Pre Mechanical Engineering	Pre-Mechanical Engineering
9	Pre Mechanical Engineering	Mechanical Engineering
10	Pre Mechanical Engineering	Pre-Biology
11	Pre Mechanical Engineering	Pre-Mechanical Engineering
12	Undecided	Undecided
13	Pre Computer Engineering	Pre-Computer Engineering
14	Pre Mechanical Engineering	BA Communications
15	Pre Mechanical Engineering	Mechanical Engineering

The data in tables 1-3 were analyzed to gauge the effect of the ME150 class on students' retention by comparing it against the mechanical engineering students' retention before the inception of the ME150 class in the spring of 2019. In Spring 2019, there were 11 pre-major students out of 14 total students. Out of these 11 students, 9 students (or 82%) continued in the ME program. In Fall 2019, there were 9 pre-major students out of 15 students total. Six out of these 9, or 67%, stayed in ME. Lastly, in Spring 2020 there were 12 pre-major students out of a total of 15 students. From these, 8/12 (or 67%) remained in the ME program. It is worth mentioning here that internal SOE data show that after two years of entering the pre-mechanical engineering program, only 50% are retained. The data above for ME150 shows a higher retention rate than average SOE retention records, see figure 20. However, we believe that data from more future semesters, or a longitudinal study, is needed to better track the eventual retention of such students in the ME program, keeping in mind that retention is affected by many factors and not just the ME150 experience.

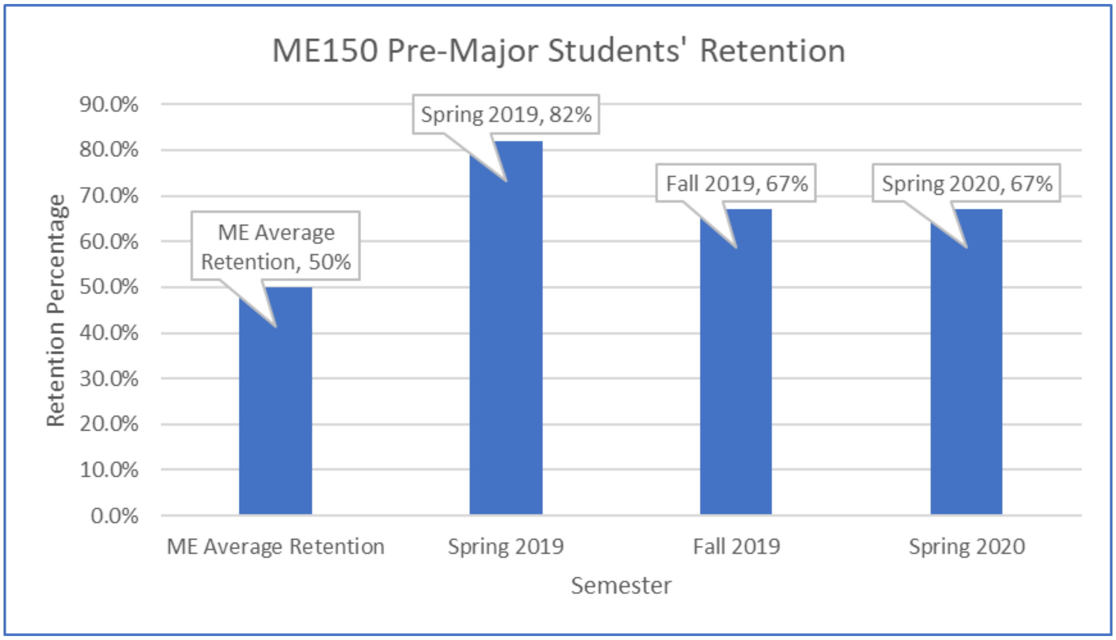


Figure 20. ME150 Pre-major students' retention in three semesters.

Summary and Conclusions

In summary, the objective of developing the ME150 class at the Mechanical Engineering Department, University of New Mexico was presented. The design of the course was discussed, and various research and laboratory activities conducted by the students were presented. The results of students' surveys in 2019 and 2020 were discussed to gauge the success of the course in meeting its objectives. Students were able to realize the importance of math and physics in mechanical engineering applications such as automobile, aircraft, and power plants. Students expanded their knowledge about the new trends in jobs' evolution in mechanical engineering in the aerospace, bioengineering, manufacturing, and robotics. Students continue to value the interactive learning process, which was emphasized before by several works[13,14,15,16]. At least 62% stated that the course increased their commitment to an engineering career. The course received an overall rating between good to excellent from 88% of the students.

In conclusion, the initial assessment of the course after three semesters revealed that the new course is on track to achieve its goals. Tacking the progress of the students toward the completion of their engineering degree will provide additional data to update the assessment. Surveying more students in the upcoming semesters would provide additional data to increase the accuracy of assessment. It would be helpful to compare students' enrollment/retention in Spring and Fall of 2020 with future enrollment to access the overall impact of COVID-19 on students' enrollment/retention.

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AHMED HASAN, Ph.D.

Dr. Hasan currently serves as an Adjunct and Assistant Research Professor of Mechanical Engineering at the University of New Mexico. His research interests include integrated management of sustainable development, thermodynamics, Contaminant Transport encompassed the physics and chemistry of the fate and transport of contaminants in aquifers, hazardous and mixed waste; performance assessment of the high-level radioactive waste repositories; colloidal transport of contaminants and; disposal of Greater-than-Class C radioactive waste.

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