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Impact of Self-Directed Learning Modules on Preparing Students to Take the FE Exam

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Abstract

Previous studies have shown that a positive relationship exists between engineering students' self-directed learning abilities and online learning experience. The objective of this study is to evaluate the impact of using self-directed learning modules (SDLMs) to prepare students to take the Fundamentals of Engineering (FE) exam. The SDLMs include micro review and example videos for concepts included in the NCEES Reference Handbook, live/recorded review sessions with students, and FE-style assessments for each topic covered in the FE exam where the problems are drawn randomly from a large bank of problems. The SDLMs were implemented in ME 416 FE Exam Review at the University of Idaho to prepare students to take the FE Exam. The course was offered first in person, followed by hybrid and entirely online during the Covid-19 pandemic, which allowed us to evaluate the effect of SDLMs to prepare students to take the FE Exam. Evaluation methods include students' feedback in the course evaluations and surveys, history of students' performance on practice exams as well as FE exam results in each topic area. Results indicate a high level of satisfaction with the FE exam preparation process leading to performance above the national average in both overall pass rate and most topic areas.

1. Introduction

Almost all of the world's most pressing problems would benefit from Science, Technology, Engineering, and Mathematics (STEM)-based solutions [1]. Fourteen of the sixteen fastest-growing "industries of the future" are STEM industries, and all of the top twenty-five degrees by pay and demand are in STEM subjects. By 2025, 3.5 million STEM jobs will be open in the United States alone. To deliver efficient and effective STEM education to most students is challenging due to the many dimensions involved in the teaching and learning processes. One of them is that GenZ students always have access to modern technology such as the internet, computers, and smartphones, which could have a strong influence on their learning needs. GenZ students are more self-paced, self-directed, and independent, with freedom of what/how they learn [2]. STEM educators must modify their teaching methods to meet GenZ learning needs best. Kalkhurst [3] pointed out that "Gen Z is disrupting decades-long practices in our education system, forcing colleges and universities to adapt at a rapid pace or become irrelevant." GenZ students are accomplished self-learners and can process information at a fast pace, and it is important to be brief and visual to capture and hold their attention [4, 5]. Additionally, students need a more efficient way to learn STEM concepts, i.e., without reading everything in textbooks and lecture notes. This is important when they prepare for multiple final exams within a short period and, in particular, when students prepare for the National Council of Examiners for Engineering and Surveying (NCEES)'s FE Exam.

Based on the literature, interviews with students, and observations of the faculty in the past years, we see two critical challenges and issues in STEM education: (1) **existing courses are not designed to match Generation Z (GenZ) (ages 17-22) learning needs and there is too much material to digest when there is a learning need**; and (2) **there is a lack of evaluation results for new learning modules designed for GenZ students.** This study aims to address these two challenges and issues in current STEM education by developing and implementing novel learning modules for various mathematics and engineering courses and using rigorous assessment methods to evaluate their effectiveness. For this study, the research questions we investigate are:

RQ1: *how can we design learning modules that best meet GenZ students' learning needs?*
RQ2: *How effective are our learning modules?*

Previous studies in the literature have shown that self-directed learning modules (SDLMs) are strong factors in influencing students' learning outcomes in traditional learning settings or distance learning environments [6]. SDLMs have been implemented to undergraduate medical students in biochemistry [7], medical student knowledge and attitudes regarding decision-making capacity [8], teaching kinematics [9], and pharmacists' patient care process course [10], etc.

Watson et al. [11] used the Self-Directed Learning Readiness Scale (SDLRS) [12, 13] to measure the changes in self-directed learning readiness among their undergraduate engineering students during the COVID-19 pandemic (Spring 2020). Results showed that SDLRS scores increased during six weeks of emergency online instruction but juniors were the only group who did not experience gains in SDLR, which needed further study in subsequent semesters. Chou [14] focused on the correlation and cause-effect relationships between students' self-directed learning abilities and learning outcomes using two experimental studies in electronic engineering, one in a computer lab and one in an online environment. They found that the computer lab study showed a positive relationship between engineering students' self-directed learning abilities and learning outcomes. However, the online learning environment indicated that students' self-directed learning abilities do not influence their outcomes. This inconsistency was attributed possibly to factors like randomization, online learning environment, self-directed learning ability, and online instructional activity. Morrison et al. [15] developed a flexible, self-directed learning module to raise students' awareness of their self-directed learning to identify their strengths and weaknesses, make informed decisions about their own learning, and improve their test-taking skills in the International English Language Testing System (IELTS) Exam preparation.

There are various research studies on improving student performance in the FE exam. Swenty et al. [16] evaluated whether a review course increased FE Exam preparedness by measuring their confidence and performance on FE-style questions in their courses. Overall, they found that the FE review course improved perceived student confidence in taking the overall FE exam and topic-specific sections. However, confidence and exam performance were not strongly correlated. Kiriazes and Zerbe [17] evaluated the department policy and programs that support NCEES FE exam preparation in civil and environmental engineering using an online survey that had 143 respondents from 51 universities across the US. The survey revealed the largest roadblocks are the unclear process of registration, lack of free study resources, and limited investment by students in studying. The survey respondents "expressed the need for a credited FE review course to relieve the burden of identifying and accessing study materials, self-teaching exam content not covered in courses, and reserving studying time on top of large course loads." The survey also revealed the students' need to have sufficient access to exam preparation material and knowledge of the exam process. The lack of visible department-provided study material might be why many students rely on external study materials such as Youtube videos and the NCEES practice exam.

To the authors' best knowledge, there is no study evaluating the impact of SDLMs to prepare students to take the FE exam in Mechanical Engineering with extensive evaluation results. This study will address this using recently developed SDLMs at the University of Idaho, which are evaluated by students' surveys that indicate their confidence levels before and after taking SDLMs, their performance in the FE Exam in Mechanical Engineering and their comments on the strengths and weaknesses of SDLMs. Given the learning needs of GenZ students [3, 4], the authors of this paper designed, developed, and implemented SDLMs to capture and hold students' attention and use FE-style problems to give them immediate feedback, which is important to learn STEM concepts [4]. Key components of SDLMs include:

(1) Micro review and example videos (5-7 minutes) for concepts included in the NCEES Reference Handbook. The knowledge areas for the concepts in the Mechanical Engineering exam include Mathematics; Probability and Statistics; Computational Tools; Ethics and Professional Practice; Engineering Economics; Electricity and Magnetism; Statics; Dynamics, Kinematics and Vibrations; Mechanics of Materials; Material Properties and Processing; Fluid Mechanics; Thermodynamics; Heat Transfer; Measurements, Instrumentation and Controls; and Mechanical Design and Analysis.
(2) Live/recorded review sessions with students' questions & answers (~70 minutes). The recorded sessions covered the most important concepts tested in the FE exam and were posted online for students.
(3) FE-style assessments for each topic covered in the FE exam where the problems are drawn randomly from a large bank of problems.
(4) Handouts that summarize the tips and/or clarify the most common mistakes from students.

Compared to traditional learning modules, these new SDLMs materials will not use students' time significantly and therefore allow students to learn concepts more efficiently and choose which concepts to review and learn. Before the computer-based test (CBT) was implemented for FE exam at the University of Idaho Testing Center in Spring 2014, we used CE 411 FE Review class for every student in the college of engineering to take and prepare for the FE Exam. Every student met individual faculty experts in each topic areas in-person and then took the paper-based FE exam. Between Spring 2014 and Spring 2018, while using the CE 411 materials for the FE CBT exams we saw a sharp decline in students' performance with the lowest pass rate at 65%, which was 13% lower than the national average pass rate 78%. To address this decline, we started developing and implementing SDLMs in Fall 2018 and modified CE 411 to be ME 416 FE Exam Review. Although we didn't anticipate COVID-19 impact in Fall 2019, the implementation of SDLMs allowed students to continue learning online without meeting instructors face-to-face. Nonetheless, we still meet students live on ZOOM for the 1st session of the course to give an overview of the course and answer questions from students.

The objective of this study is to evaluate the impact of using SDLMs to Prepare Students to Take the FE Exam in the discipline of Mechanical Engineering.

2. Methodology

For details on the design, development and implementation of SDLMs, please refer to the previous ASEE papers by the same team [5, 18]. There were 14 topic areas in the FE Exam. We combined Mathematics and Probability and Statistics into one learning module and similarly combined Electricity and Magnetism and Measurement into one learning module as well, which resulted in 12 learning modules.

These assessments are available in two varieties:

- Topical Assessments: These are for students to take after fully preparing themselves via video modules and instructor review and/or questions. Students had four attempts at passing each assessment; they are graded and will comprise the grades for the course.
- Mock-mini Exam: Students also have access to a mock-mini, 1/4-length FE exam, which is designed to mimic the composition and pace of the genuine 110-question FE exam. They are given 1-1/2 hours to complete this 28-question exam and a passing score is 20 correct answers. This exam is optional but can count toward students' grades (see below).

As for grading, students will have 12 class assessments during the semester for the 12 learning modules. A passing grade in the course is achieved by Passing 11 of the 12 class assessments. If students pass the mock-mini FE exam, this will count as passing three class assessments. If students complete the course survey, it will count as passing one class assessment. We also set up a criterion to urge students to pass at least three assessments by a certain time in the semester to have a passing grade at the time of issuing early warning grades and pass at least six assessments by certain time to have a passing mid-term grade. We also requested students to email the instructor a schedule (on a week-by-week level) as to what FE modules they plan to work on/complete each week of the semester with a plan to complete all the assessments before the dead week of each semester. To encourage more students to take the FE exam, students who registered for the FE Exam can receive a $100 reimbursement thanks to a donor's generosity. Students who passed the FE Exam before graduation are eligible to receive an additional $100 from the Department of Mechanical Engineering (ME). Starting in Fall 2021, we started inviting students who had just passed the FE exam in the previous semester to share their experiences of taking the exam and answer questions from students in our review class. Students found that this had helped them understand the structure of the FE exam and develop a general strategy and methodology to better prepare them for it. Additionally, we posted videos showing how to register for the exam and coordinated with the local testing center to provide the available seats and dates in the center to take the FE exam. Starting in Spring 2023, we required all ME students to register for the FE exam before their graduation.

The effectiveness of SDLMs in preparing students for the FE Exam was evaluated using three data sets: (1) students' performance in the FE exam every semester for the past nine years, (2) students' confidence levels before and after completing SDLMs, and (3) selected students' comments in course evaluations.

3. Results and Discussion

3.1 Overall FE Exam results

Implementation of SDLMs is completed in our ME 416 FE Exam Review course. Assessments for each FE Exam topic are provided to prepare students for the FE Exam. Most of these 30-minute assessments each contain seven problems and a passing score for each is five correct answers. Two of the assessments (Ethics and Econ) each contain five problems and a passing score for each is three correct answers. Based on the data released to the University of Idaho by NCEES, Figure 1 shows the pass rates of our students, pass rates of all examinees from ABET comparator program and the number of students who took the FE exam from Spring 2013 to Fall 2022. Details of students' performance in each topic area from Spring 2014 to Fall 2022 are presented in Appendix A. As shown in Figure 1, students' pass rate in FE exam is consistently higher (except in Spring 2013) than the national pass rate before FE CBT test was implemented in Spring 2014. After that, students' pass rate declined to the lowest point (65%) in Spring 2017. It recovered slightly to 73% in fall 2018 when we started implementing SDLMs. Since then, students' pass rate has increased steadily to 100% in Fall 2020, when the national pass rate showed a plateau. After that, both the students' pass rate and national pass rate declined but our students' pass rate is consistently higher than the national rate with a magnitude of at least 9%. From Fall 2018 to Fall 2022, about 45% of ME 416 students took the FE Exam.

Appendix A shows the time history of students' performance in each topic area tested in the FE exam in Mechanical Engineering. Overall, students' performance in all areas is strong as all of them either met or partially met the expected achievement levels (details for one semester in fall 2020 is presented in Appendix B). It proved the feasibility of our SDLMs across the whole spectrum of topics after implementing the online approach, as performance is equally good in all areas. We are also aware of potential areas where students' performance can be further improved to be consistently above the national average, including mathematics, probability and statistics, thermodynamics, heat transfer, and electricity and magnetism.

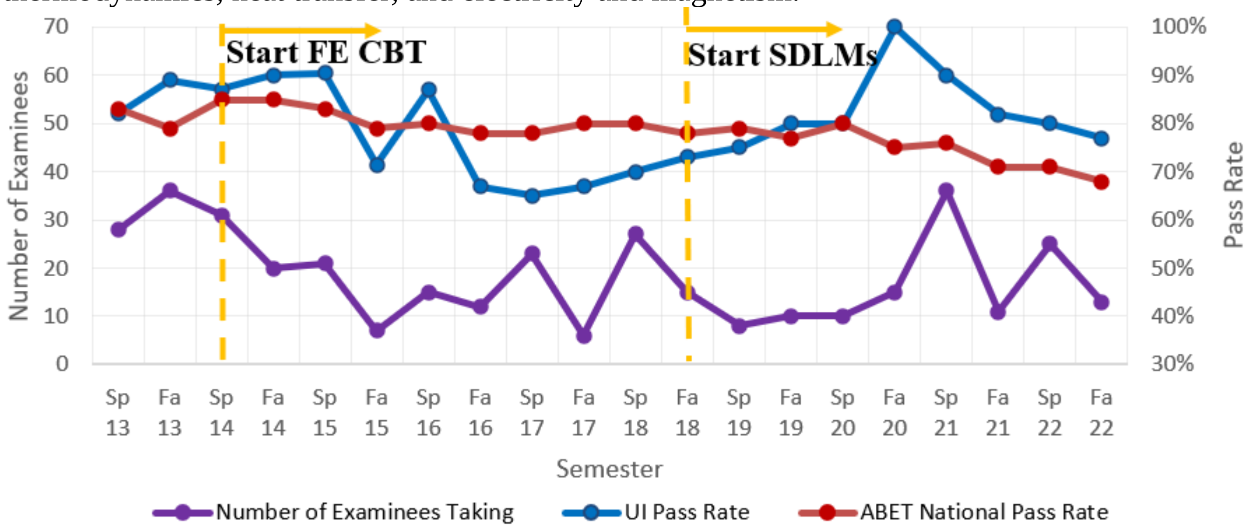

Figure 1. Number of our students who took the FE Exam and their pass rates from Spring 2013 to Fall 2022 with comparison to ABET national pass rates.

3.2 Use of FE Exam results in ABET assessment reports

Each semester after we received FE exam results from NCEES. ABET assessment reports for students' performance in all topic areas of the FE exam were prepared. Herein, the assessment report for Fall 2020 is presented in Appendix B. The report covers the Mechanical Engineering Educational Objective, targeted ABET Learning Outcome, and Area of Focus followed by Assessment Tool and Analysis of Findings. In the section for Assessment Tool and Analysis of Findings, various topics are grouped into five categories: Mathematics, Science, Engineering, Ethics and Professional Practice, and Engineering Economics. For each category, we used the NCEES "Institution Average Performance Index" (IAPI), the national average "ABET Comparator Average Performance Index" (ACAPI), and the "ABET Comparator Standard Deviation" to evaluate student performance in each of the topic areas. Their performance was categorized into four expectation achievement levels: exceeded, met, partially met, and not met. No corrective action was recommended for topics that met expectations but action items were recommended for topics that partially met expectations. We found no topics that either exceeded expectations or not met expectations. The report was reviewed and approved by the ABET committee of Mechanical Engineering Department.

There were 15 students taking the FE Exam with a 100% pass rate in Fall 2020 but eight topic areas partially met expectations. Although students only had three areas that partially met expectations in Fall 2022, the overall pass rate was 77%. This observation suggests no strong correlation between students' overall pass rate and their performance in individual topic areas.

3.3 Students' confidence levels before and after completing SDLMs

All students were asked to complete a course survey to indicate their confidence levels for each of the following topics covered in SDLMs using the following scale before and after taking the course:

- 1 = confused by language and concepts in the FE reference manual on this subject area
- 2 = can follow solutions on this subject area by watching others work through the solution
- 3 = can solve each problem in this subject area using the FE reference manual and by collaborating with others in more than three minutes
- 4 = can solve each problem in this subject area independently using the FE reference manual in more than three minutes
- 5 = can solve each problem in this subject area independently using the FE reference manual in about three minutes

Results are presented in Appendix C where the blue and red columns indicate students' confidence levels before and after completing SDLMs. The percentage of increase in the confidence level after completing SDLMs is presented at the top of the red column. Table 1 presents the mean and standard deviation for students' confidence level increase after completing SDLMs for six semesters since Spring 2020.

It showed that students always felt more confident after completing SDLMs, which were consistent with students' comments in course evaluations (next section). The mean of confidence level increase ranges from 17% to 33% while the standard deviation of the increase ranges from 3% to 14%. The highest increase was observed for Ethics and Professional Practice, Dynamics, Kinematics, and Vibrations, Thermodynamics, Electricity and Magnetism, and Engineering Economics (≥ 29%), which showed that students found SDLMs on these topics had helped them greatly. It should be noted that a higher confidence level increase for a topic didn't necessarily indicate a better quality of SDLMs for that topic. For example, the increase for Mechanical Design and Analysis was the lowest (17%) but students' confidence level for that topic already achieved a high level before they completed SDLMs.

Table 1. Mean and Standard Deviation (SD) for Students' Confidence Level Increase after Completing SDLMs from Spring 2020 to Fall 2022 (N=6)

Topics	Mean	SD	Topics	Mean	SD
Mathematics	26%	7%	Mechanics of Materials	21%	3%
Probability and Statistics	29%	8%	Material Properties and Processing	27%	3%
Ethics and Professional Practice	33%	5%	Fluid Mechanics	24%	7%
Engineering Economics	29%	11%	Thermodynamics	30%	9%
Electricity and Magnetism	30%	7%	Heat Transfer	27%	14%
Statics	22%	6%	Measurements, Instrumentation, and Controls	27%	4%
Dynamics, Kinematics, and Vibrations	31%	7%	Mechanical Design and Analysis	17%	7%

3.4 Students' comments in course evaluations

Students' comments from ME 416 course evaluations for SDLMs from Fall 2019 to Fall 2022 were summarized in two categories, i.e., strength/positive aspects and areas in the course that can be further improved. When more than one student had the same/similar comments, multiple factors will be added at the end of the comment. For example, "×2" indicates that two students had the same/similar comments.

Students liked the following aspects of SDLMs:

- Great class. I feel that it helped me immensely towards passing my FE (×7).
- I really liked how different professors talked about their fields. Each instructor was knowledgeable and extremely helpful (×14).
- Great organization, clear-cut course objectives and clear expectations of what is needed to pass the course (×8).
- I like the online format and ZOOM meetings as I don't have to attend class and can focus on the material and learn at my own pace. Low impact on the schedule was very helpful to balance workload yet provided a strong structure to guide studying should the student need it. Professors were also very accommodating to myself and at least one other student who were scheduled to take our exam before the scheduled end of the course. Of specific note, I enjoyed the number of attempts available on the mock exam. There was enough to completely recreate the length of a real FE exam and more to practice the pacing of the exam (×14).

- All the review and example videos were incredibly helpful and I hope to keep access to them in the future (×12).
- The unit assessments allowed me to only study the information I felt uncertain of. This made it so I did not need to spend unnecessary time on the content I was already familiar with (×2).
- Refunding some/all of the cost of taking the exam is a good incentive (×2).

There are also areas students thought SDLMs could be further improved:

- Make the practice questions more related to the actual FE in terms of the actual content, difficulty, and time of the problems (3 minutes per question) instead of homework-type questions that can take 10-15 minutes. This will be much more realistic when taking the FE (×7).
- Providing solutions to all problems (right or wrong). This was a review course that didn't allow us to review the solution paths of problems that we got right or wrong (×4).
- I do like the idea of being able to do the course on our own time but it is very hard to stay with this delivery. I would have of course enjoyed an in-person lecture each Thursday because there was nothing really keeping me involved meant that it took a back burner until the end of the semester (×10).
- More step-by-step example problems and less theory for the videos (×2).
- I am sure this is common but a greater pool of questions per section, or a better randomizer would help greatly. Often I got repeat "freebie" questions.

4. Conclusions

The use of SDLMs to improve students' performance in FE Exam in Mechanical Engineering at the University of Idaho has proven to be very successful, which is supported by the overall pass rate and students' performance in each topic area compared to ABET National Average, consistently (much) higher confidence levels before and after completing SDLMs and students' comments/feedback in course evaluations.

- Analysis of students' performance in FE exam in Fall 2020 and Fall 2022 shows that an overall high pass rate on the exam doesn't necessarily indicate a good performance (met expectation) in all topic areas.
- Students' split on the benefits of offering the FE Exam Review course completely online over in-person. While some students liked the online format so they could decide when and what to learn, other students preferred in-person meetings with weekly deadlines so they could better control their study pace and be more involved with the instructors during the semester.

Future work will continuously improve SDLMs based on students' suggestions and their performance in the FE Exam:

- Modify and add more practice problems in the assessments to be more FE related.
- Provide solutions to some problems that students often make mistakes.
- Add more example videos on topics where students' performance partially met in our ABET assessment reports.

- Implement SDLMs to lower-level engineering courses covering the specific topics in the FE exam. This will help pre-assess students' preparation for upper-level courses and identify topics/concepts that need to be revisited and strengthened in early weeks of these courses.

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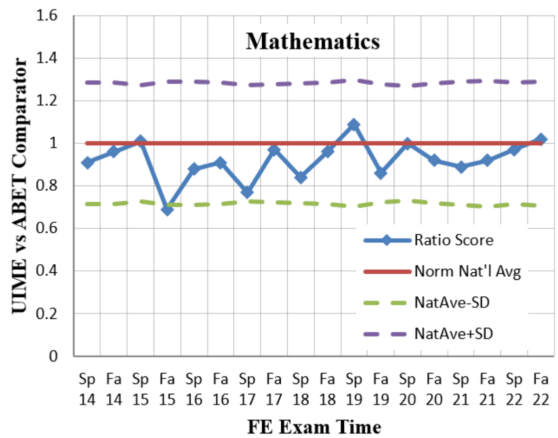
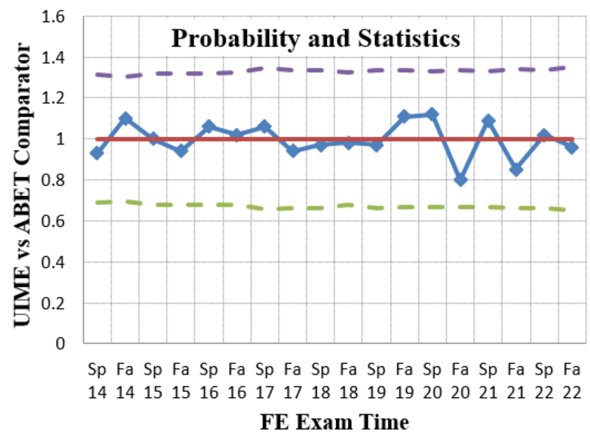
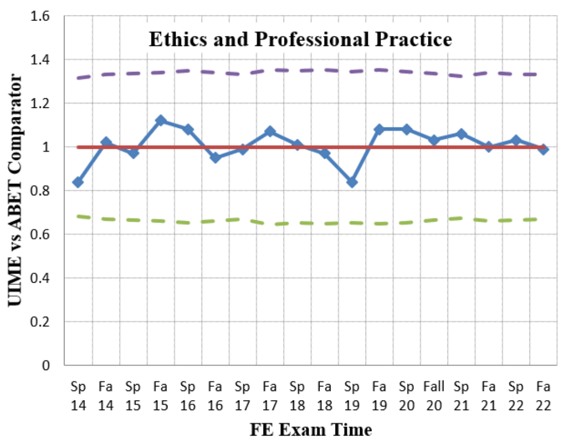
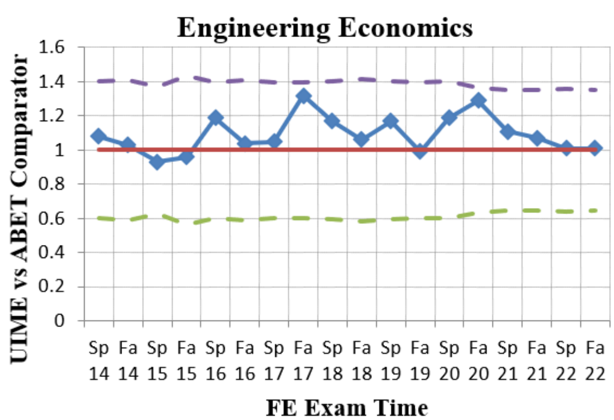
Appendix A. Students' Performance in FE Exam

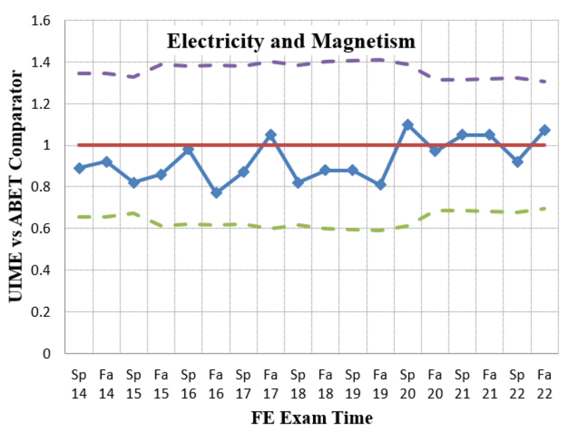
Multi-year variation of the normalized IAPI for each section of the FE exam analyzed in this assessment report. The lower and upper limits delineate achievement levels are also represented to highlight the lower and upper achievement (ACAPI ∓ σ-ACAPI) /ACAPI, where the σ-ACAPI used was for the current semester.

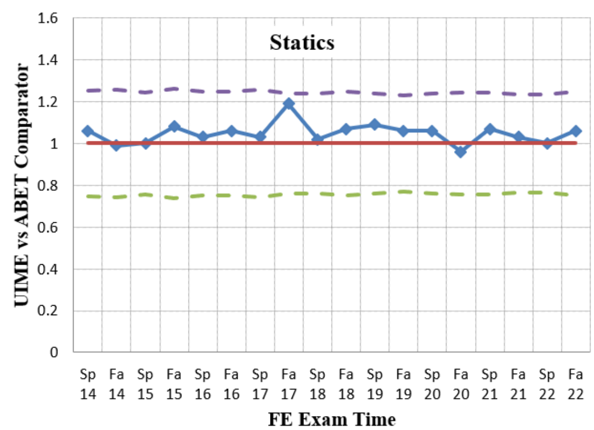


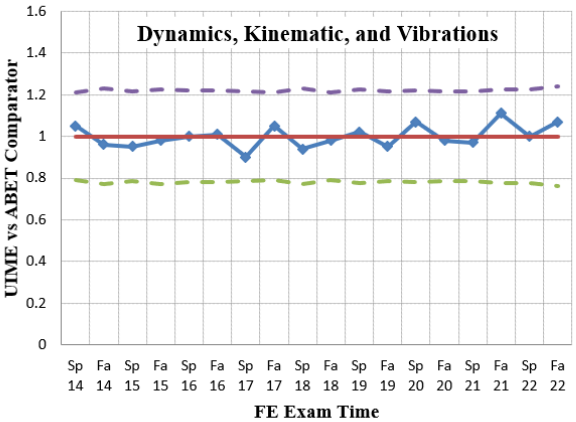


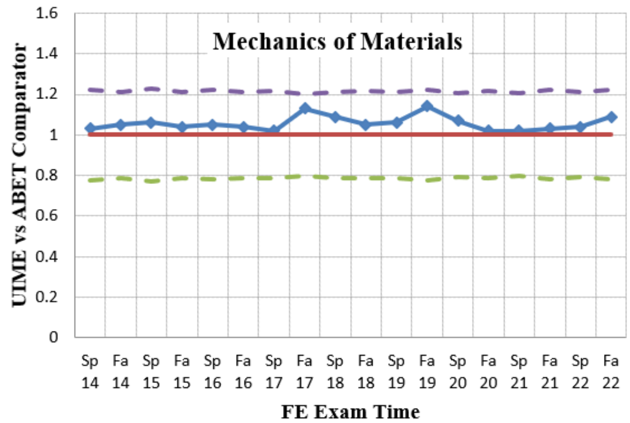


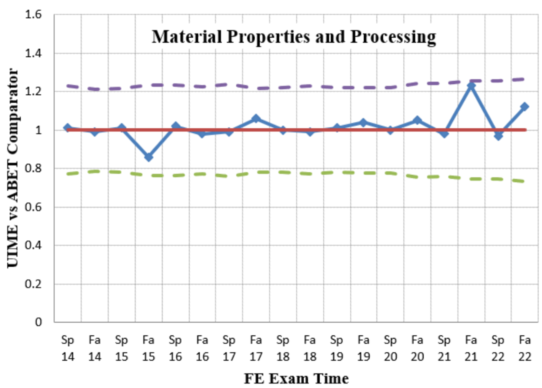


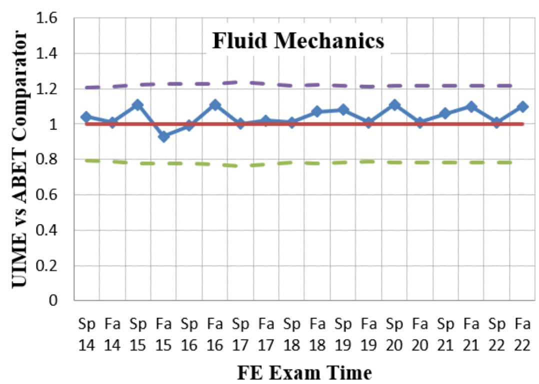


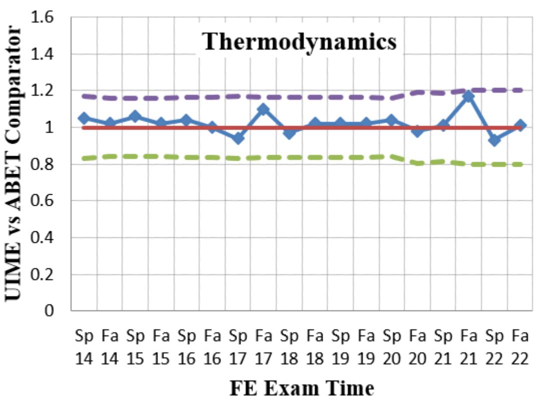


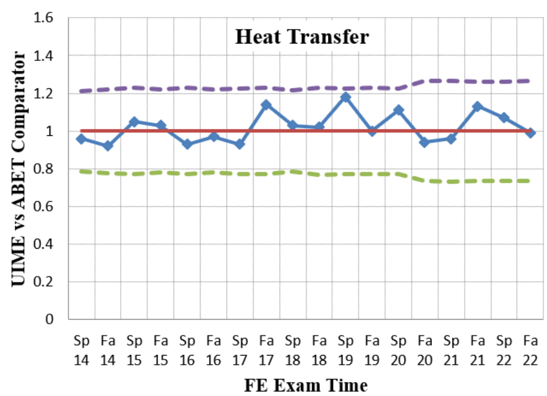

Dynamics, Kinematic, and Vibrations
UIME vs ABET Comparator
FE Exam Time

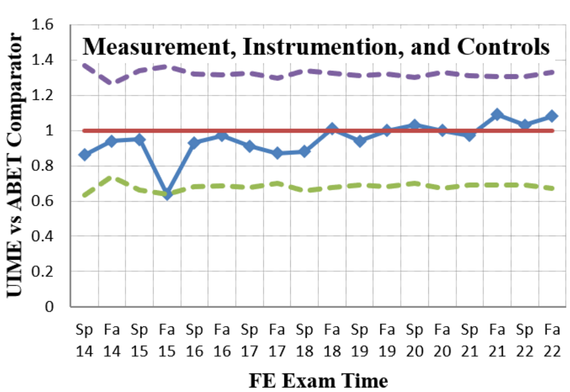

Mechanics of Materials
UIME vs ABET Comparator
FE Exam Time

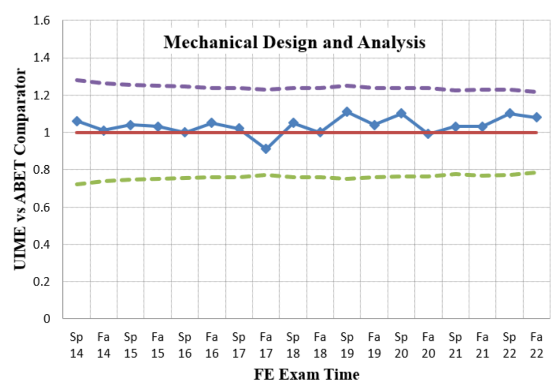

Material Properties and Processing
UIME vs ABET Comparator
FE Exam Time


Fluid Mechanics
UIME vs ABET Comparator
FE Exam Time


Thermodynamics
UIME vs ABET Comparator
FE Exam Time


Heat Transfer
UIME vs ABET Comparator
FE Exam Time


Measurement, Instrumention, and Controls
UIME vs ABET Comparator
FE Exam Time


Mechanical Design and Analysis
UIME vs ABET Comparator
FE Exam Time

Appendix B FE Exam Results for ABET Assessment Reports in Fall 2020

1. **Course/Location:** Fundamentals of Engineering (FE) Exam

2. **Date:** Fall Semester, 2020

3. **Connection with ME Program Educational Objectives**
   - Graduates of the program will be proficient engineering problem solvers capable of identifying, formulating, and solving engineering problems by applying their knowledge of mathematics, science, and engineering.
   - Graduates of the program will assume expanded responsibilities for collaboration with others including public and worker safety, environmental protection, ethical and legal practices, formal project management and involvement in professional communities or society at large.

4. **Connection with ABET Learning Outcomes**
   - Upon graduation, students will have the ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics.
   - An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

5. **Area of Focus**
   - Application of mathematics, science and engineering to solve problems from all levels of undergraduate engineering education.
   - Application of practices, concepts and methods from (i) ethics and professional practice, and (ii) engineering economics to solve engineering problems.

6. **Assessment Tool and Analysis of Findings**

Graduates of the mechanical engineering program are encouraged to take the FE examination. The NCEES provides the College of Engineering reports each spring and fall semester summarizing student performance on the FE exam and compares these results with national averages. The FE exam problems are categorized into different sections, according to the discipline they belong. To assess this outcome, the following sections of the exam were selected and grouped into three categories:

1. *Mathematics*
   - Mathematics
   - Probability and Statistics

2. *Science:*
   - Electricity and Magnetism

3. *Engineering:*

- Statics
- Dynamics, Kinematics and Vibrations
- Mechanics of Materials
- Materials Properties and Processing
- Fluid Mechanics
- Thermodynamics
- Heat Transfer
- Measurements, Instrumentation and Controls
- Mechanical Design and Analysis

4. *Ethics and Professional Practice*
5. *Engineering Economics*

For each of these exam sections, the NCEES report presents the "Institution Average Performance Index" (IAPI), the national average "ABET Comparator Average Performance Index" (ACAPI), and the "ABET Comparator Standard Deviation", labeled here as σ-CAPI. The IAPI and ACAPI are on a scale from 0 to 15.

Student performance in each of the FE exam sections is categorized into four expectation achievement levels as follows

- EXCEEDED: when the IAPI > ACAPI + σ-ACAPI
- MET: ACAPI < IAPI ≤ ACAPI + σ-ACAPI
- PARTIALLY MET: ACAPI − σ-ACAPI < IAPI < ACAPI
- NOT MET grade: IAPI < ACAPI - σ-ACAPI

Target: Careful monitoring of the FE exam results in a section should be performed in subsequent semesters whenever the performance level is in the NOT MET level in a given semester. If the NOT MET level is recorded in two consecutive semesters, corrective actions should be undertaken. These corrective actions can include: (1) the addition of theoretical materials to the online database of SDLMs, (2) the addition of practice problems to the online database of SDLMs, (3) reinforcements of concepts, methods and examples in various other undergraduate courses related to the section in question, (4) communication with faculty and departments involved in teaching courses related to the section in question, and alerting them that students tend to score lower (i.e., NOT MET criterion) in the particular FE exam section, so they can identify the reasons for weak scores and improve student preparation in that particular area.

Analysis of Findings:

Table B1. Results for the Mathematics category

FE Exam Section	IAPI	ACAPI	σ-ACAPI	ACHIEVEMENT LEVEL
Mathematics	9.1	9.9	2.8	**PARTIALLY MET**
Probability and Statistics	7.7	9.6	3.2	**PARTIALLY MET**

Table B2. Results for the Science category

FE Exam Section	IAPI	ACAPI	σ-ACAPI	ACHIEVEMENT LEVEL
Electricity and Magnetism	9.6	9.9	3.1	PARTIALLY MET

Table B3. Results for the Engineering category

FE Exam Section	IAPI	ACAPI	σ-ACAPI	ACHIEVEMENT LEVEL
Statics	9.1	9.5	2.3	PARTIALLY MET
Dynamics, Kinematics, and Vibrations	9.2	9.4	2.0	PARTIALLY MET
Mechanics of Materials	9.5	9.3	2.0	MET
Material Properties and Processing	9.9	9.4	2.3	MET
Fluid Mechanics	9.4	9.3	2.0	MET
Thermodynamics	9.1	9.3	1.8	PARTIALLY MET
Heat Transfer	9.2	9.8	2.6	PARTIALLY MET
Measurements, Instrumentation, and Controls	9.4	9.4	3.1	MET
Mechanical Design and Analysis	9.2	9.3	2.2	PARTIALLY MET

Table B4. Results for the Ethics and Professional Practice and Engineering Economics

FE Exam Section	IAPI	ACAPI	σ-ACAPI	ACHIEVEMENT LEVEL
Ethics and Professional Practice	11.3	11.0	3.7	MET
Engineering Economics	12.8	9.9	3.6	MET

A multi-year trend of the ratio IAPI/ACAPI is presented in the plots included in Appendix A. In these plots, the ratio IAPI/ACAPI representing the relative performance of the students at the University of Idaho, is compared with the national average of 1. The lower and upper limits to delineate achievement levels are also represented to highlight the lower and upper achievement (ACAPI ∓ σ-ACAPI) /ACAPI, where the σ-ACAPI used was for the current semester. As can be observed from the plots in Appendix A, the normalized IAPI in all sections is within acceptable levels.

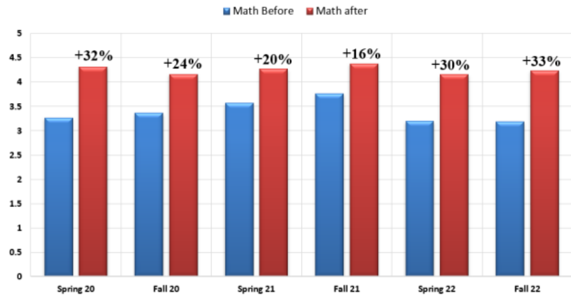
7. Interpret Findings

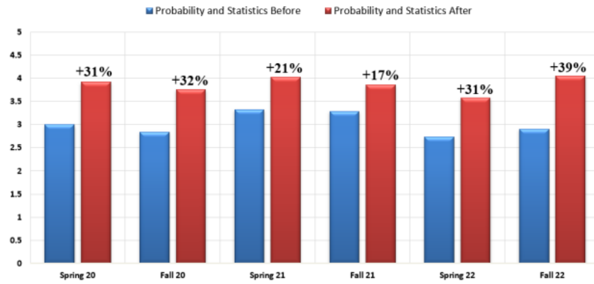
In the three categories (Mathematics, Science and Engineering), there were eight sections that PARTIALLY MET EXPECTATIONS including three sections in Mathematics and Science and five sections in Engineering categories. All other four sections in the Engineering category and the categories for Ethics and Professional Practice and Engineering Economics have recorded an achievement level of MET EXPECTATIONS. This means that for these sections, the IAPI measure was greater than the ACAPI.

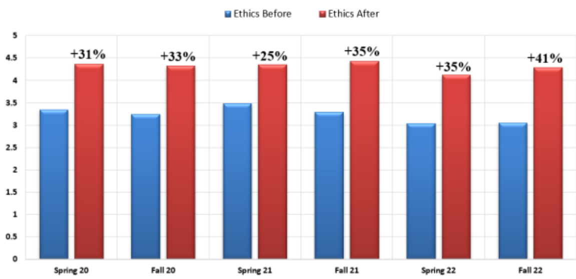
8. Use of Results

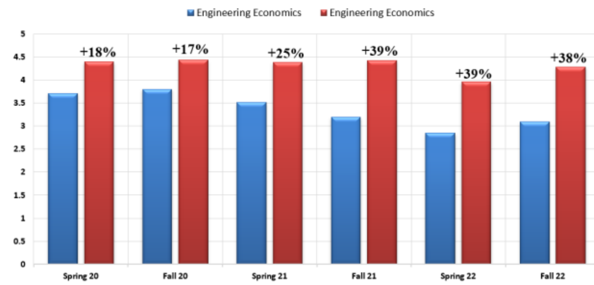
Since the target has been met in the five categories, no corrective action needs to be taken at this time. The assessment reports will continue in the upcoming semesters.

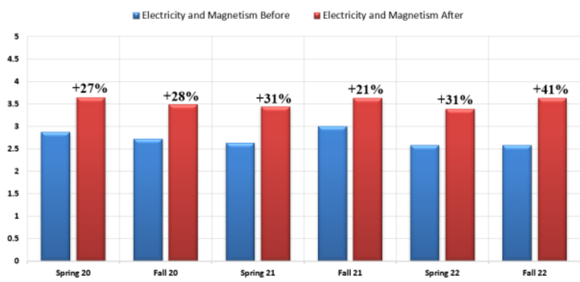
Appendix C Students' Confidence Levels before and after Completing SDLMs

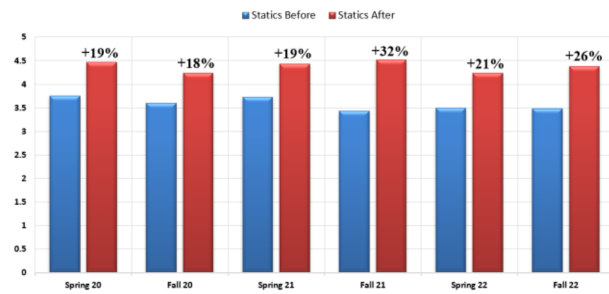


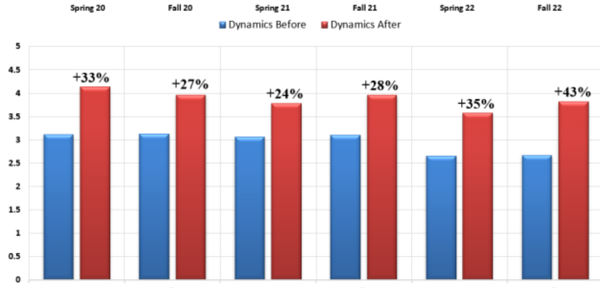


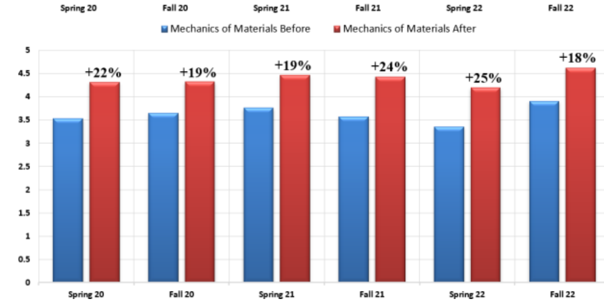


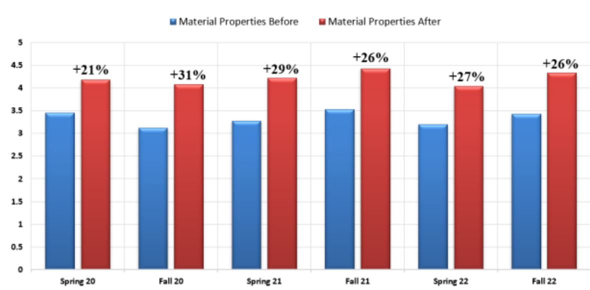


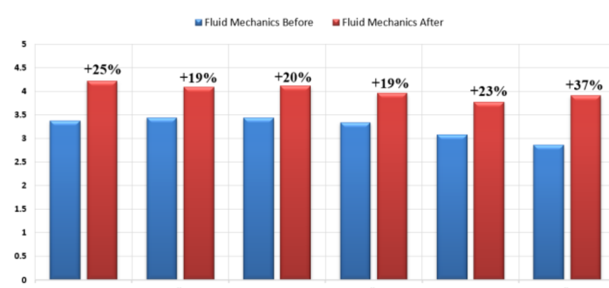


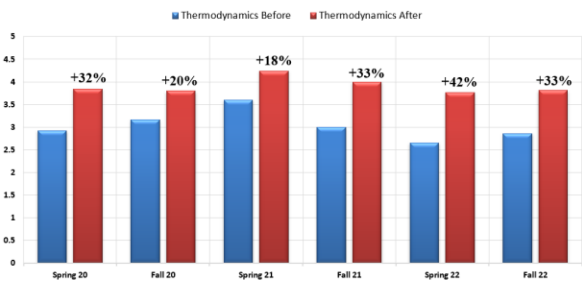


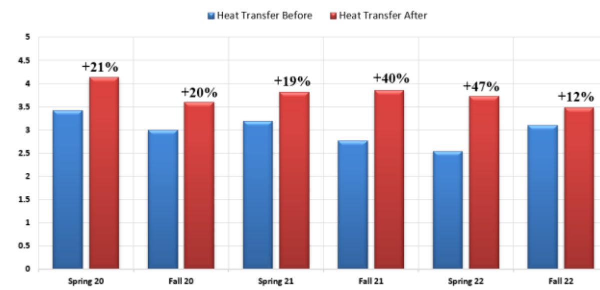


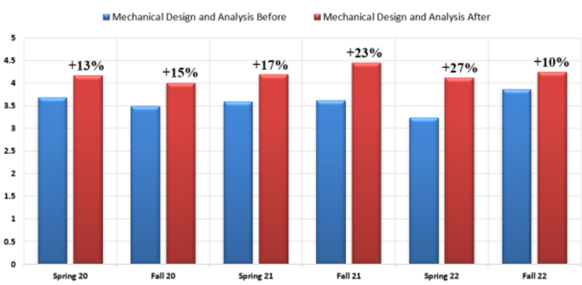


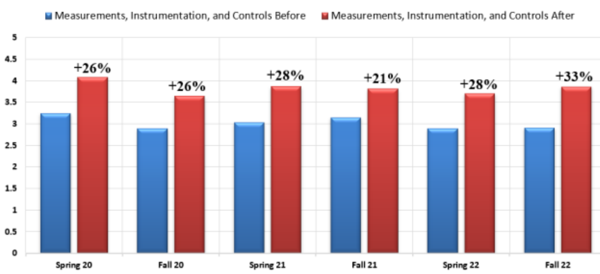





Thermodynamics Before
Thermodynamics After
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
+32%
+20%
+18%
+33%
+42%
+33%
Spring 20
Fall 20
Spring 21
Fall 21
Spring 22
Fall 22


Heat Transfer Before
Heat Transfer After
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
+21%
+20%
+19%
+40%
+47%
+12%
Spring 20
Fall 20
Spring 21
Fall 21
Spring 22
Fall 22


Mechanical Design and Analysis Before
Mechanical Design and Analysis After
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
+13%
+15%
+17%
+23%
+27%
+10%
Spring 20
Fall 20
Spring 21
Fall 21
Spring 22
Fall 22


Measurements, Instrumentation, and Controls Before
Measurements, Instrumentation, and Controls After
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
+26%
+26%
+28%
+21%
+28%
+33%
Spring 20
Fall 20
Spring 21
Fall 21
Spring 22
Fall 22