CRITERION 4. CONTINUOUS IMPROVEMENT

This section discusses improvements to our *Engineering Physics (EP)* program during the last ABET cycle (2012-2018). In general, these improvements were made as the result of a whole series of different assessment results, which can be roughly categorized into: *Program Quality* and *Program Outcomes Assessments*. The *Department of Physics* utilizes a well-defined set of approaches and tools for the different types of assessment, and their timelines are briefly summarized below.

***Program-Quality Assessment* – Tools and Timeline**

Program Quality can be closely correlated with *a) quality of instruction* and *b) relevance/extent of course offerings* in the program.

Quality of Instruction is regularly assessed by the following means:

Student Evaluations *(done for every course each semester)*

NMSU requires that students be given the opportunity to fill out a *Student Evaluation* form for each course near the end of a semester. Among others, the student evaluation has several questions about the student's perceived quality of instruction.

Pre-Requisite Tests *(done for most of physics undergraduate courses each semester)*

Instructors of various physics courses administer a *Pre-Requisite Test* at the beginning of a course. The main goal of the *Pre-Requisite Test* is to identify whether instruction of necessary pre-requisite materials from previous courses was adequate.

Faculty *Annual Performance Reports* *(once per year)*

Each faculty member is required to submit an *Annual Performance Report* (APR) of his/her performance over the past year. NMSU uses the *Digital Measures* system for the evaluation of individual faculty performance in the areas of scholarship/research, teaching, service and outreach, depending of the faculty's allocation of effort. For the teaching portion of the APR, faculty members are usually expected to include up to three independent measures of teaching effectiveness for courses that he/she taught in the previous year. Some acceptable measures are summaries of student feedback related to teaching experience, self-reflection and discussion of perceived strength or weaknesses in teaching, class-room visits and an evaluation by other faculty members and/or representatives from NMSU's *Teaching Academy*, and/or data on student performance for course material after instruction, as evidenced by separately administered (national) tests. In cases where there are identified weaknesses in a faculty member's teaching, the *Department Head* will discuss ways to address such deficiencies with the faculty member.

In addition, more general feedback about *Program Quality* is obtained by the following means:

Input from *Engineering Physic External Advisory Board* *(at least, every other year)*

As pointed out in *Criterion 2 - Educational Objectives*, the *Engineering Physics External Advisory Board* (EPEAB) consists of members from all the program's major constituents, i.e. faculty members from other academic institutions, researchers from national laboratories, industry representatives, and *EP Program* alumni. During their on-campus site visit, the EPEAB meets with physics faculty and other program representatives, and they evaluate all aspects of the *EP Program*, including *Program Quality*. If necessary, the EPEAB report will also provide guidance for the *EP Curriculum*, including suggestions about course materials and content that may increase the *Program Quality*. For example, the EPEAB provided input about the relevance of existing courses and/or their content in the past.

Course Offerings to Individual Students *(occasionally)*

Although the *Department of Physics* has limited teaching strength and therefore course offerings are limited, many of the physics faculty members are willing to teach a course to individual *EP students* outside of the regular curriculum (with no teaching credit) to accommodate a student's curricular needs and/or interests. This is particularly important for the EP students where required courses in engineering and physics may have a time conflict. The *EP Program Committee* tries to minimize such time conflicts as much as possible, but they are occasionally unavoidable.

***Program Outcomes Assessment* – Tools and Timeline**

The assessment of *Program Outcomes* will be discussed in greater detail in section *A. Program Outcomes* below. *Program Outcomes Assessment* invokes the following tools:

Course Program Outcomes Assessment *(done for every course each semester)*

For each undergraduate course, which is or can be part of the EP curriculum (i.e. required courses or electives), the course instructors are required to measure (one or more) *Program Outcomes*, as assigned by the *Engineering Physics (EP) Outcomes Matrix*, see Table 3.2.a. in *Criterion 2 – Program Outcomes*. On rare occasions, instructors volunteer additional *Program Outcomes* metrics, beyond those assigned to the course. Non-compliance of providing the assigned *Course Program Outcomes* measures results in a deficiency in the faculty member's service contribution for that year.

Faculty *Program Outcomes* Summary Reviews *(averaging every 2 years)*

To increase faculty participation in the *Program Outcomes* reviews, individual faculty members are assigned to provide a short summary of one individual *Program Outcome*. *Program Outcomes Summary* assignments to individual faculty members are distributed about every 2 years. In general, such summaries are due along with the APR (usually, in September or October). Non-compliance of providing the assigned *Outcomes Summary* results in a deficiency in the faculty member's service contribution for that year. An example of a completed *Program Outcomes Summary* is provided in *Appendix E – Supplementary Documents*.

Senior Student Exit Interviews *(when a student graduates from the program)*

The *Head of the Department of Physics* or a designee performs a formal exit interview using the *Senior-Exit Interview Form* for each student in the graduating semester. The form has questions directly connected to *Program Outcomes*. The form used for the *Senior Student Exit Interviews* (SSEI) is provided in *Appendix E - Supplementary Documents*. Since Spring of 2018, data for the SSEI are collected electronically and stored in a designated *OneDrive* folder.

A. Student Outcomes

It is recommended that this section include (a table may be used to present this information):

A listing and description of the assessment processes used to gather the data upon which the evaluation of each student outcome is based. Examples of data collection processes may include, but are not limited to, specific exam questions, student portfolios, internally developed assessment exams, senior project presentations, nationally-normed exams, oral exams, focus groups, industrial advisory committee meetings, or other processes that are relevant and appropriate to the program.

The frequency with which these assessment processes are carried out

The expected level of attainment for each of the student outcomes

Summaries of the results of the evaluation process and an analysis illustrating the extent to which each of the student outcomes is being attained

How the results are documented and maintained

Each course instructor knows which student *Program Outcomes* are assigned to be measured in each course. The instructor will design a quantitative measure for each *Program Outcome*, if none exists. Instructors' results are documented electronically or in the *Instructors Notebooks* each time a course is taught. These measurements provide the foundation for the *Program Outcomes* Summaries, which are then documented in the *'Blue' Program Outcomes Notebook*; see *Appendix E – Supplementary Documents* for a detailed list of contents of this notebook.

The *Program Outcome Assessment Process* focuses on courses offered by the *Department of Physics*. In conjunction with this, assessment of required outcomes in the *Aerospace*, *Chemical*, *Electrical*, and *Mechanical Engineering* programs is conducted in the respective engineering departments as part of ABET accreditation for their majors (see *Criterion 3 – Program Outcomes*). Engineering faculty are represented on the *EP Program Committee*, which helps to align the curriculum and outcomes assessment for their majors with the ones of the *EP Program*. It should be noted that this makes for a particularly strong *EP Program*, with ABET *Program Outcomes (a)-(k)* being assessed in multiple departments.

Program Outcomes Assessment in the *Department of Physics*

Below, we summarize the results of *Program Outcomes Assessment* of the *EP Program* as measured in the *Department of Physics*. As mentioned above, all *Program Outcomes* were also assessed in the *Senior Student Exit Interviews* (SSEI); these are labeled as such in the Diagrams 4.3.a-k.

Program Outcome (a) - Scientific Expertise

This *Program Outcome* assesses whether students understand the basic concepts, notation, and techniques in fundamental disciplines of physics and engineering, such as mechanics, electromagnetism, thermodynamics and modern physics. Common assessment tools for this *Program Outcome* are: a) the nationally administered *Force Concept Inventory* (FCI) test (for details, see *Criterion 3 - Program Outcomes*); b) problems provided in the *TIPERs: Electricity & Magnetism Tasks* (by Hieggelke, Maloney, O'Kuma, and Kanim); c) the *Mechanics & Electricity Assessment Test* (MEAT), d) *Mastering Physics®* skill-builder assessment tools; and e) standardized questions embedded in exams, tests or quizzes.

Typically, data were collected in 200-level physics courses each time they are taught, i.e. PHYS 213, 214, 215G, 216G, and 217. In addition, there has been one measurement in PHYS 315. We also asked exiting seniors to evaluate our impact on this outcome in the *Senior Student Exit Interviews* (SSEI); see *Appendix E – Supplementary Documents*. In addition, we included the *ETS® Major Field Test in Physics* (MFT) *Subscore* for *Introductory Physics* in the assessment of this *Program Outcome*; for details, see *Criterion 3 - Program Outcomes*.

Target levels are determined by individual instructors depending on the choice of the assessment tool. Instructors, utilizing nationally-administered tests or assessment tools (i.e. the FCI or the *Mastering Physics®* skill builder assessment) will typically use the national or system average for the determination of a target. For example, when the FCI is given as a pre-test at the beginning and as a post-test at the end of the course, national data show a 48% improvement, and instructors using the FCI as the assessment tool typically use this as the target. Justification for targets, not set by national standards or similar benchmarks, are generally provided by instructors in their individual *Post Course Instructor Comment Forms,*

The results are displayed in Diagram 4.3.a. The results indicate that the level of achievement for this *Program Outcome* is above 80% of the target. Achievement of this *Program Outcome* is determined with high confidence because of the large number of assessment tools and possible comparison with nationwide data (MFT and *Mastering Physics*®).

Program Outcome (b) - Experimental Training

This *Program Outcome* is supposed to assess if a student can perform fundamental experimental studies in physics and engineering, and he/she is able to analyze the data. Common assessment tools were: a) final laboratory exam grades or embedded exam questions; b) selected laboratory homework; c) individual lab reports; d) observation of student's comfort level and/or participation in labs by teaching assistants; and e) teacher assessment of field-work participation.

Data were collected in most (but not all) courses that contain a laboratory component, i.e. PHYS 213L, 214L, 215GL, 216GL, 217L, 315L, 304, 471, 475 and 493. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI.

The target level is set by the instructor depending on the method used. In many cases, the departmental average or a B grade average is used by instructors as the target value. In other cases, however, the instructor set an appropriate benchmark based on their expectations; see individual *Post Course Instructor Comment Forms*.

The results are shown in Diagram 4.3.b, and it is apparent that almost all results are near the target levels. Achievement of this *Program Outcome* can be determined with relatively high confindence because multiple assessment tools have been used.

Program Outcome (c) - Design Abilities

This *Program Outcome* assesses the student's ability to design and implement an experimental or theoretical study to tackle physics problems in an applied context, such as economic, environmental, or societal. It was generally assessed using a) students' *Experimental Design Reports* and b) instructor's observations during various experimental and programming activities.

We expected data to be collected in relevant classes each time they were taught, i.e. PHYS 315L, 471, 475, 476 and 493. However, no data related to this outcome were collected in PHYS 471 and PHYS 475. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI.

The targets were set by instructors who measured this *Program Outcome* at 80%, see *Post Course Instructor Comment Forms.*

As can be seen in Diagram 4.3.c, the results are close to the instructors' expectations in all cases. Achievement of this *Program Outcome* is determined with comparatively low confindence because only few assessment tools are used.

Program Outcome (d) - Teamwork

This *Program Outcome* determines whether students can work as effective members of a team, and if they are able to take responsibility for some or all aspects of a common goal. This was typically assessed using *Peer Team Evaluations* in laboratory courses. Students ranked contributions and participation of their peers on a scale of 1-4.

We expected data to be collected in assigned classes each time they were taught, i.e. PHYS 315L, 471, 475 and 493. Moreover, we recently added PHYS 217L to the list of courses measuring this outcome. Except for PHYS 315L, data are relatively sparse. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI.

The targets were set by the instructors, see *Post Course Instructor Comment Forms*.

As can be seen in Diagram 4.3.d, the targets were generally met. The students usually get along well, even though there is the occasional problem. This *Program Outcomes* measure has larger scatter because the teams are typically small, i.e. statistical fluctuations are large. Moreover, achievement of this *Program Outcome* is determined with comparatively low confindence because only few assessment tools are used.

Program Outcome (e) - Problem Solving

This *Program Outcome* measures students' scientific understanding and ability to solve physics and engineering problems. It was assessed mostly by using *Graduate Record Exam* (GRE) questions embedded into exams, tests or quizzes. In PHYS 451, the FCI was used to measure this outcome.

Data were collected in assigned classes each time they are taught, i.e. PHYS 451, 454, 455, 461, 462, and 480. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI. In addition, we included the MFT *Subscore* for *Advanced Physics* in the assessment of this *Program Outcome*

All course instructors used the national norm as the target for GRE questions. We acknowledge that the standard *GRE test* limits the time students can spend on each problem, and this is quite difficult to repeat in a regular classroom setting. Therefore, it can be expected that students would typically perform at levels above the national norm.

As can be seen in diagram 4.3.e., using GRE questions and MFT results, targets were typically met and often exceeded. There are significant fluctuations in this measure because the number of students in these classes is small, typically between 10 and 20 students. Nevertheless, achievement of this *Program Outcome* is determined with high confidence because nationwide data are available.

Program Outcome (f) - Professional Responsibility

This *Program Outcome* is supposed to measure whether students demonstrate high standards of ethics and integrity in their professional activities. Some of the assessment tools of this *Program Outcome* were: a) separate *Subscores* in essays or project reports; b) student use of citations in essays; c) attendance and participation; d) student participation and contributions to team projects; and e) external reviews of 'professionalism' of student presenters.

This outcome was measured in a variety of courses (although not necessarily consistently), such as PHYS 303V, 305V, 315, 315L, 451, 462, 471, 475, 480, 488, and 493. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI.

Targets were set by the instructors of each course, see *Post Course Instructor Comment Forms*.

As can be seen in diagram 4.3.f, the targets were typically met. Achievement of this *Program Outcome* is determined with some confindence because multiple assessment tools were used.

Program Outcome (g) - Communication Skills

This *Program Outcome* measures the students' ability to present information (both oral and written) in an effective, well-organized, logical, and scientifically-sound manner. The assessment of this *Program Outcome* was generally done using written reports in lab and lecture courses with an emphasis on writing quality and grammar, and from oral presentations.

This outcome measured in all PHYS 315L, and some PHYS 461, 471, 475 and 493 courses. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI.

Targets were set by instructors, see *Post Course Instructor Comment Forms*.

As can be seen in diagram 4.3.g, students' communication skills are generally adequate. Achievement of this *Program Outcome* is determined with comparatively low confindence because only few assessment tools are used.

<u>Program Outcome (h) - Societal Impact</u>

This *Program Outcome* attempts to measure students' appreciation of the human dimension and the impact of their profession in a diverse social, cultural and economic environment. Assessment of the *Program Outcome* was done using: a) *Subscores* in essays or project reports; b) specific homework assignments; and c) class participation.

This outcome was measured in many PHYS 305V, 315, 451, 462, 480, and 489 courses. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI.

Targets were set by the instructors, see *Post Course Instructor Comment Forms*.

As can be seen in diagram 4.3.h, targets were generally met. Achievement of this *Program Outcome* is determined with comparatively low confindence because only few assessment tools are used.

<u>Program Outcome (i) - Lifelong Learning</u>

This *Program Outcome* attempts to measure students' understanding of the need for lifelong learning to accommodate rapid changes in science and technology. Assessment of the *Program Outcome* was done using: a) *Subscores* in essays or project reports; b) specific homework assignments; and c) *Subscores* in oral presentations.

This outcome was measured each time the relevant classes were taught, i.e. PHYS 315, 451, 462, 480, and 489. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI. In addition, student participation in the MFT was taken as a measure of achievement for this *Program Outcome*

Targets were set by instructors, see *Post Course Instructor Comment Forms*.

As can be seen in diagram 4.3.f, the targets are mostly met. The achievement of this *Program Outcome* has been a longstanding challenge, indicating the need of continued targeted effort in future courses. Achievement of this *Program Outcome* is determined with comparatively low confindence because only few assessment tools are used.

<u>Program Outcome (j) - Contemporary Issues</u>

This *Program Outcome* determines students' preparation to become effective members of the society throughout their careers. Assessment of this *Program Outcome* was generally done using essays or project reports or presentations, either through the choice of presentation topic or separate *Subscores*.

This *Program Outcome* was measured in several PHYS 303V, 305V, 315, 451, 461, 462, 480, 488, and 489 courses. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI.

Targets were set by instructors, see *Post Course Instructor Comment Forms*.

As can be seen in diagram 4.3.j, targets were generally met or exceeded. Achievement of this *Program Outcome* is determined with comparatively low confindence because only few assessment tools are used..

<u>Program Outcome (k) - Technical Know-how</u>

This *Program Outcome* measures students' ability to understand how to use widely-spread state-of-the-art tools used in modern engineering practice. Assessment of this *Program Outcome* uses: a) in-lab observations in the Advanced Physics Lab courses; b) exam questions or standardized questions from the *Fundamental Engineering (FE)* exam in the *Math Methods in Physics* course; and c) a final software design challenge assignment in the *Computational Physics* course.

This outcome was measured in lab courses each time they were taught, i.e. Physics 315L, 395, 471, 475, 476, and 495. We also asked exiting seniors to evaluate our impact on this outcome in the SSEI.

Targets were set by individual instructors, see *Post Course Instructor Comment Forms*.

As can be seen in diagram 4.3.k, targets were generally met, except for one poor performance in one semester of PHYS 395. Achievement of this *Program Outcome* is determined with comparatively low confindence because only few assessment tools are used.

Course Program Outcomes measurements are provided in the *Instructors Notebooks* for individual courses, and all *Program Outcome* measures are compiled in the *Program Outcomes Notebooks*.

Diagram 4.3.a. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (a) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) and Major Field Tests (MFT) are included.*

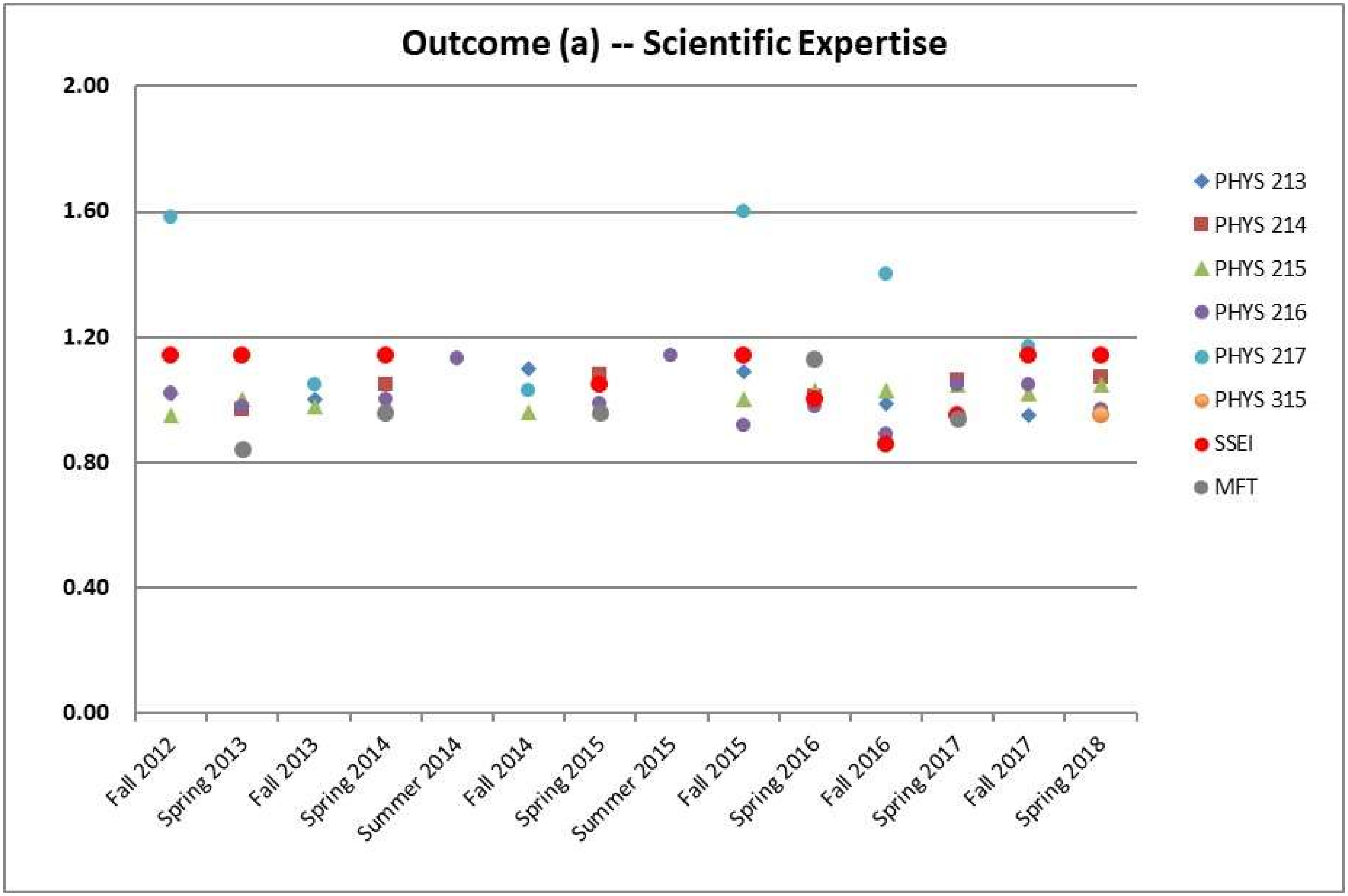


Diagram 4.3.b. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (b) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) are included.*

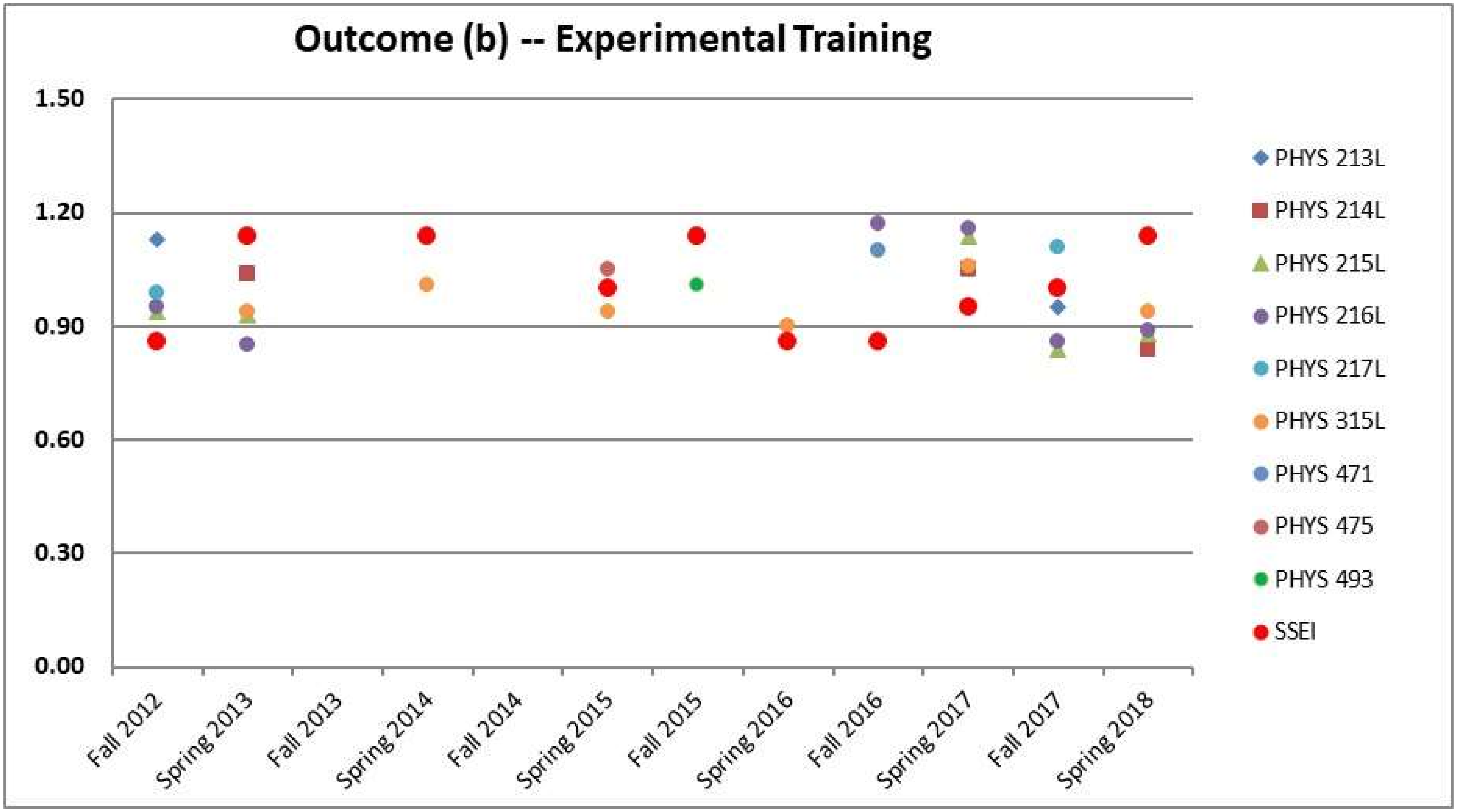


Diagram 4.3.c. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (c) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) are included.*

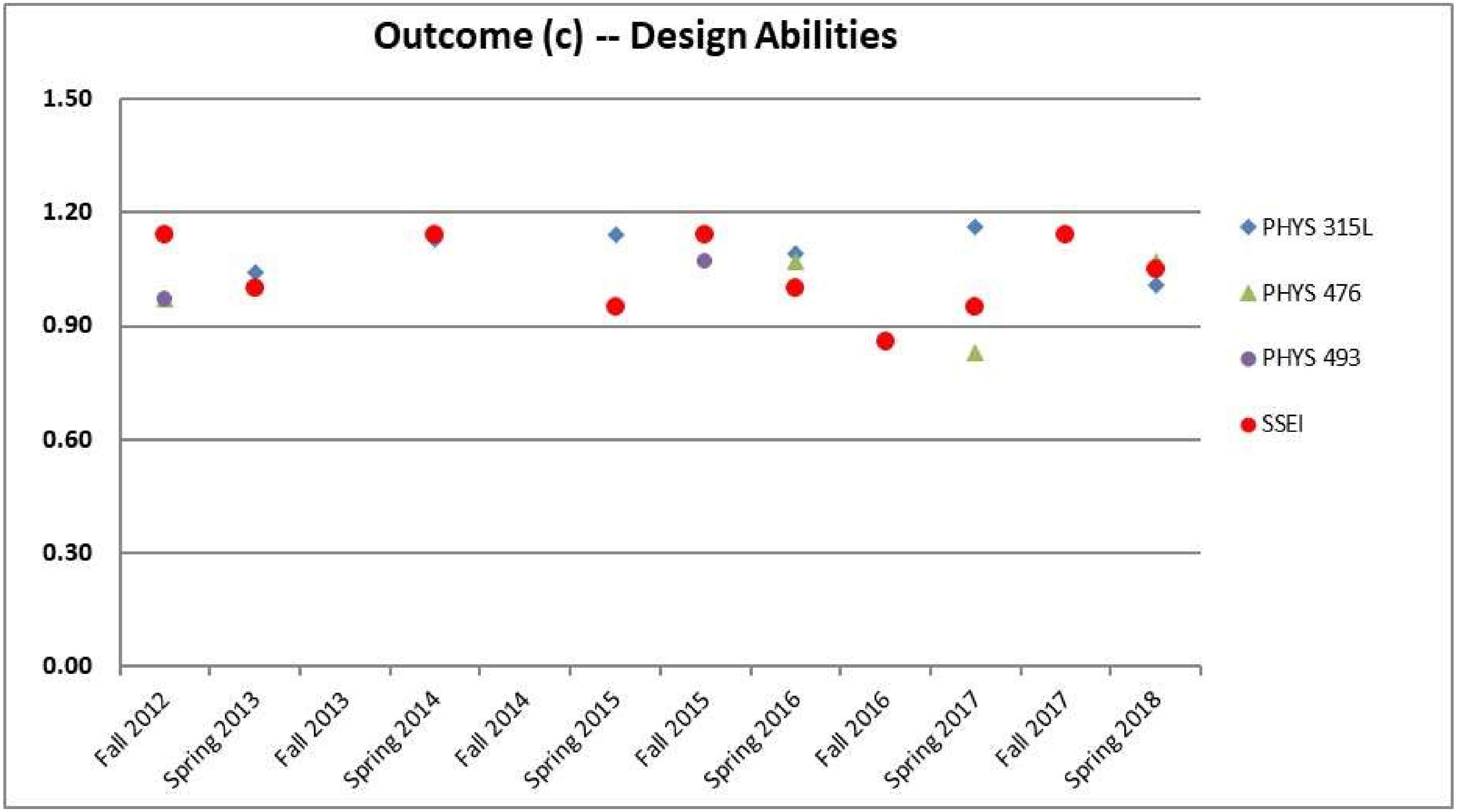


Diagram 4.3.d. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (d) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) are included.*

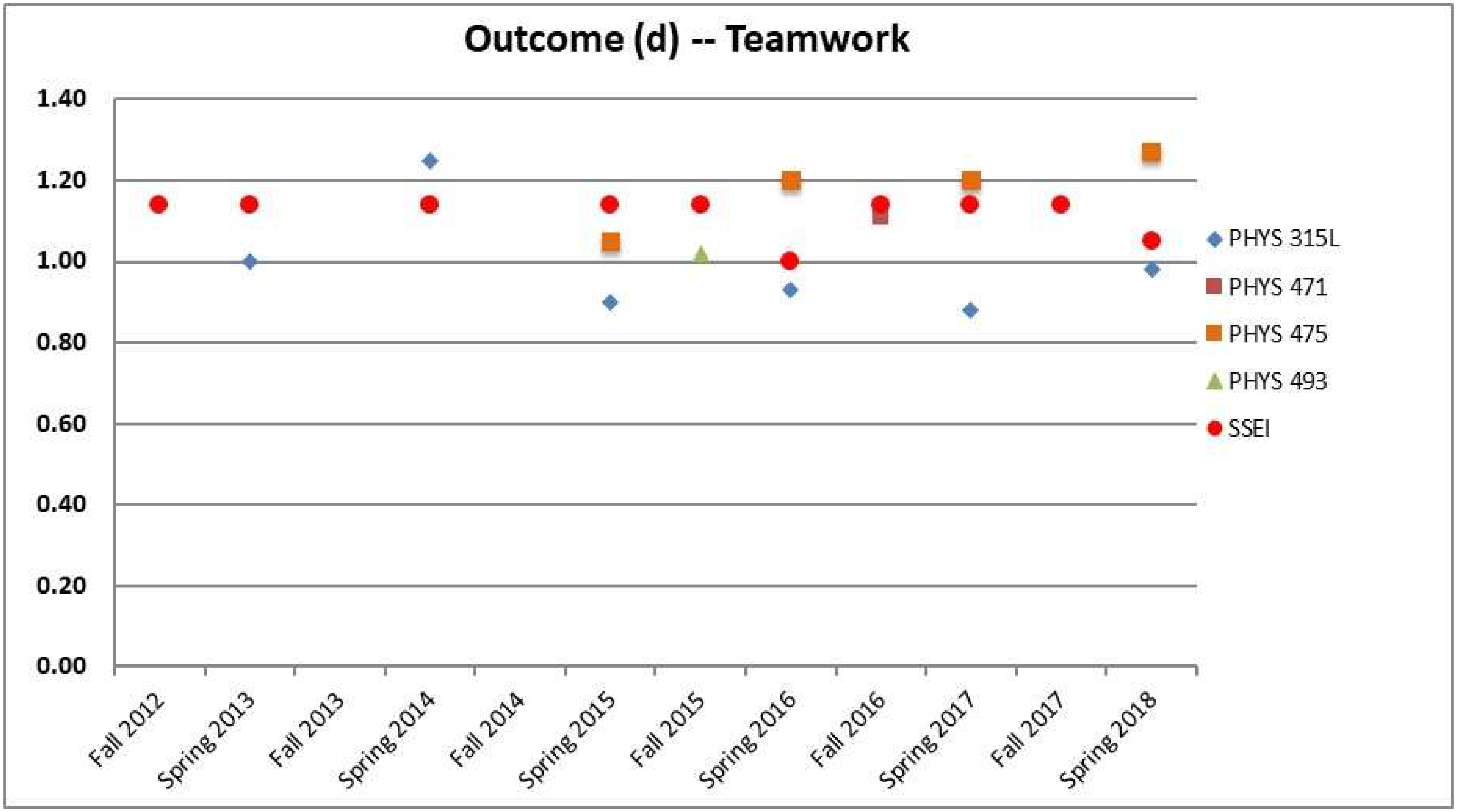


Diagram 4.3.e. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (e) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) and Major Field Tests (MFT) are included.*

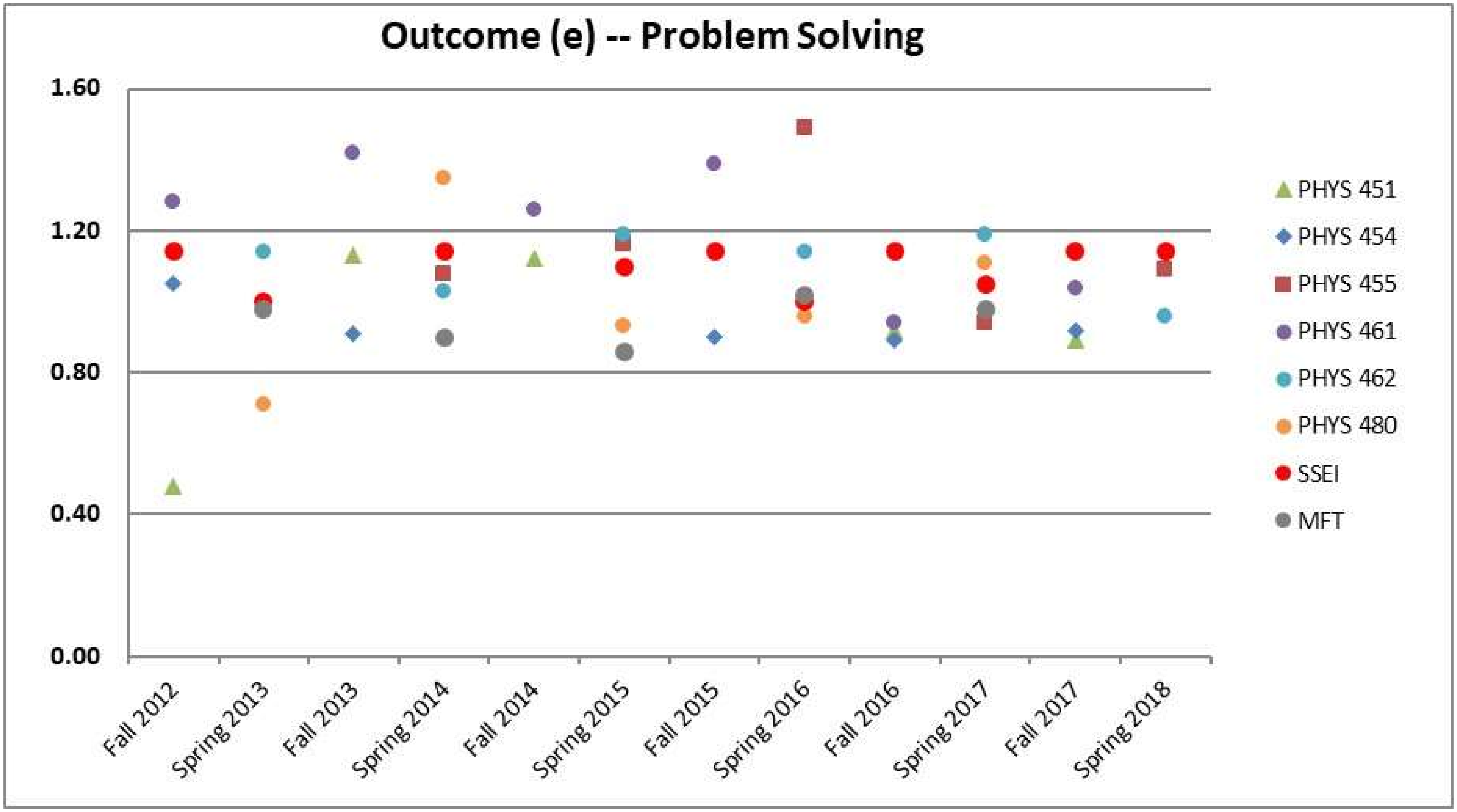


Diagram 4.3.f. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (f) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) are included.*

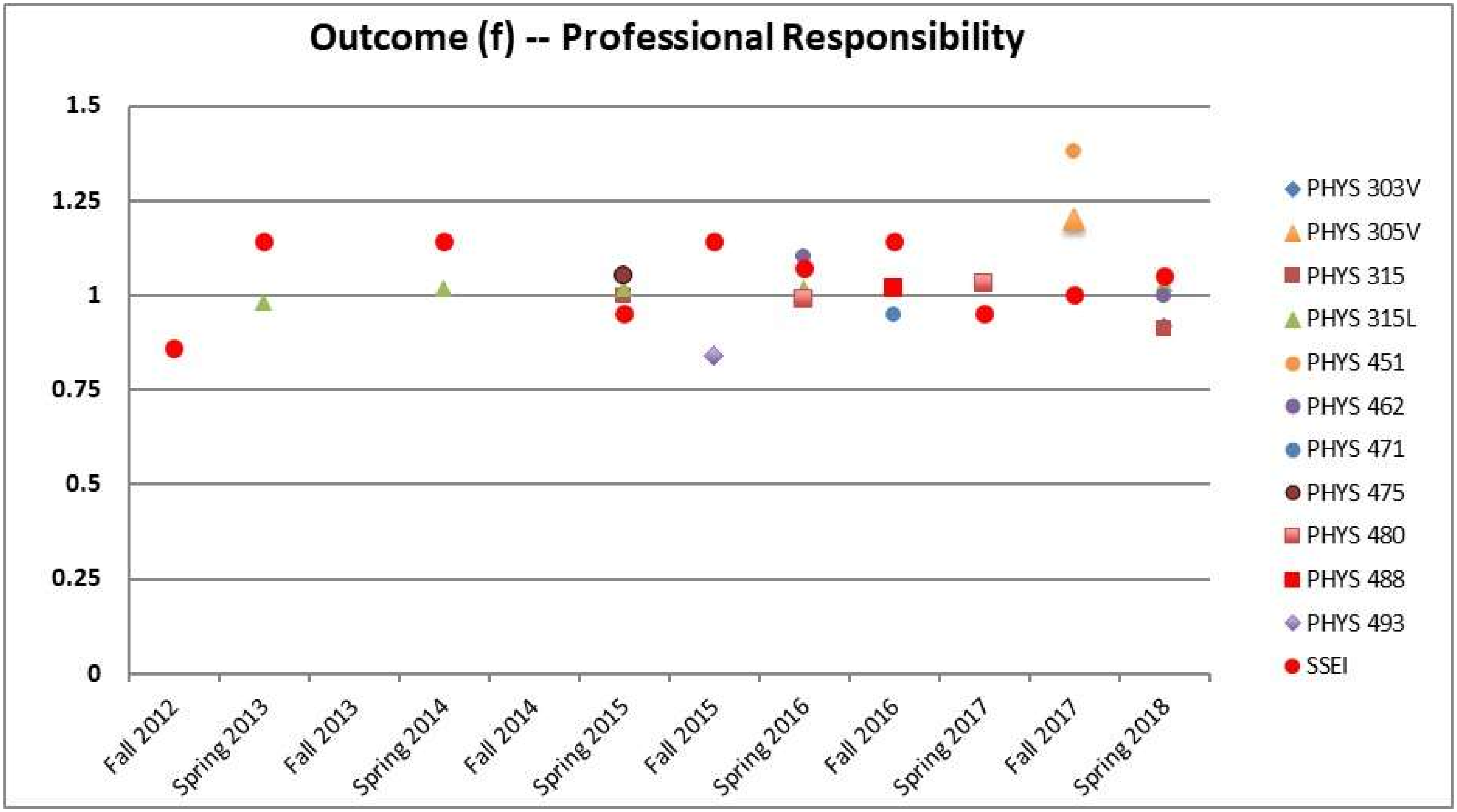


Diagram 4.3.g. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (g) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) are included.*

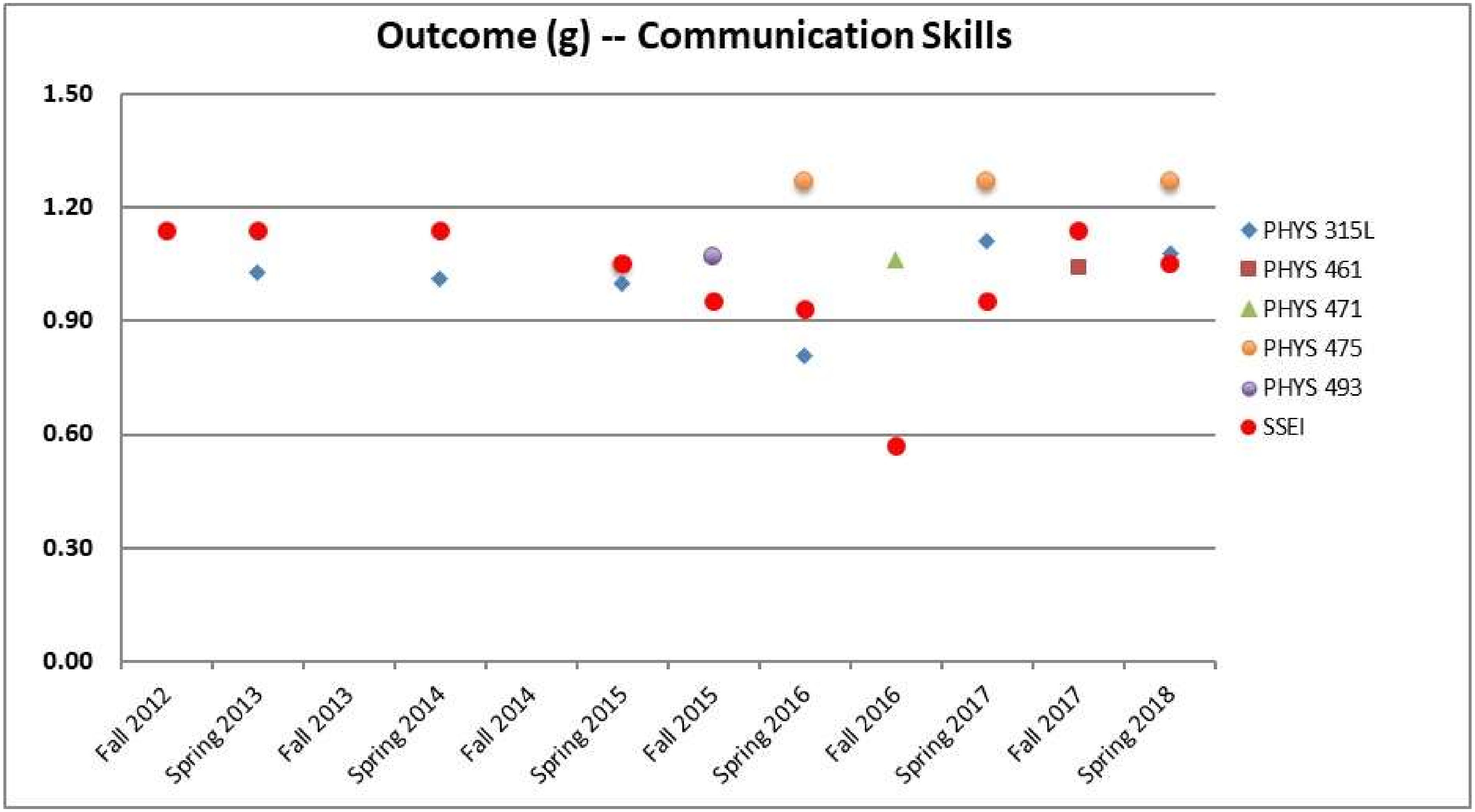


Diagram 4.3.h. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (h) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) are included.*

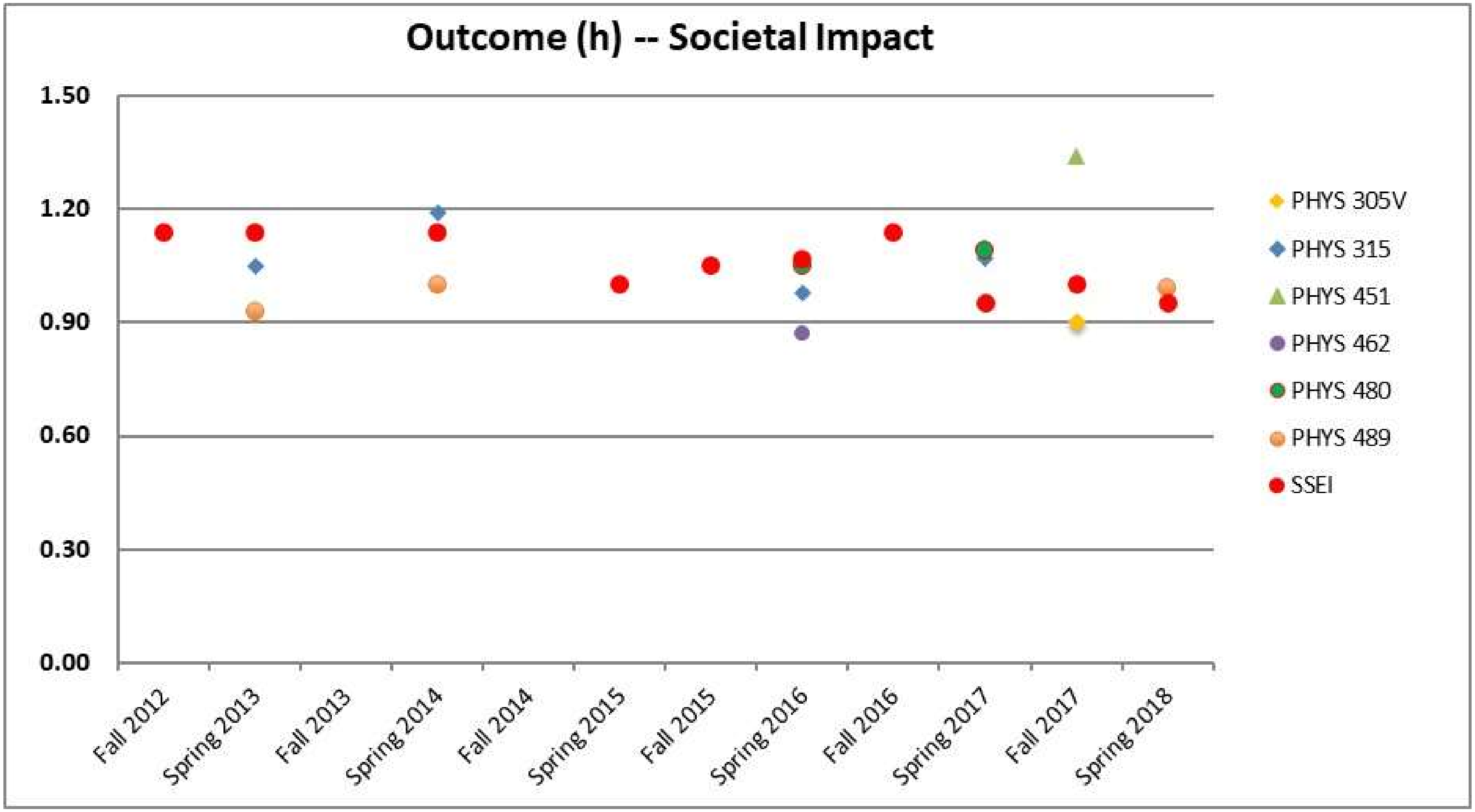


Diagram 4.3.i. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (i) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) and Major Field Tests (MFT) are included.*

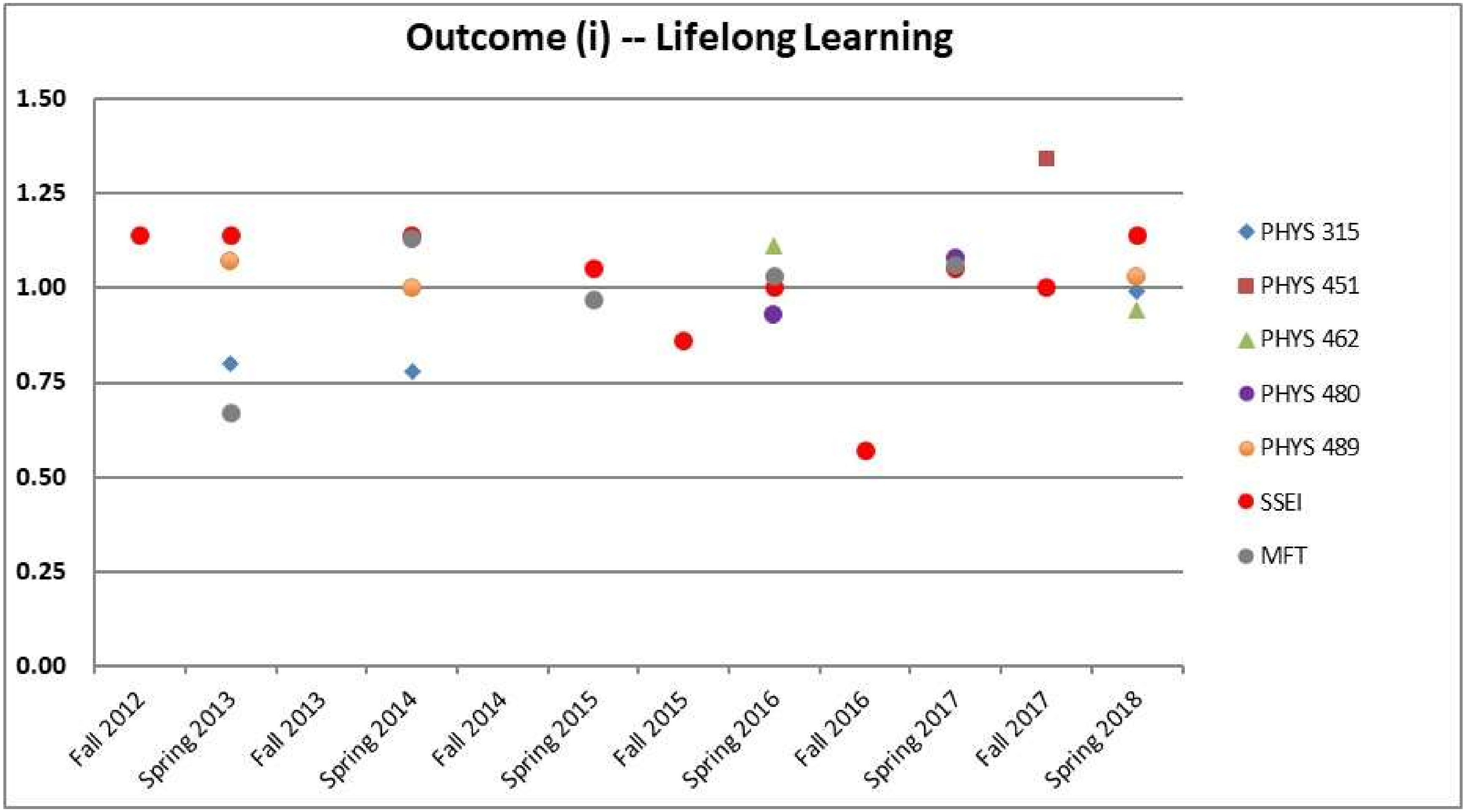


Diagram 4.3.j. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (j) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) are included.*

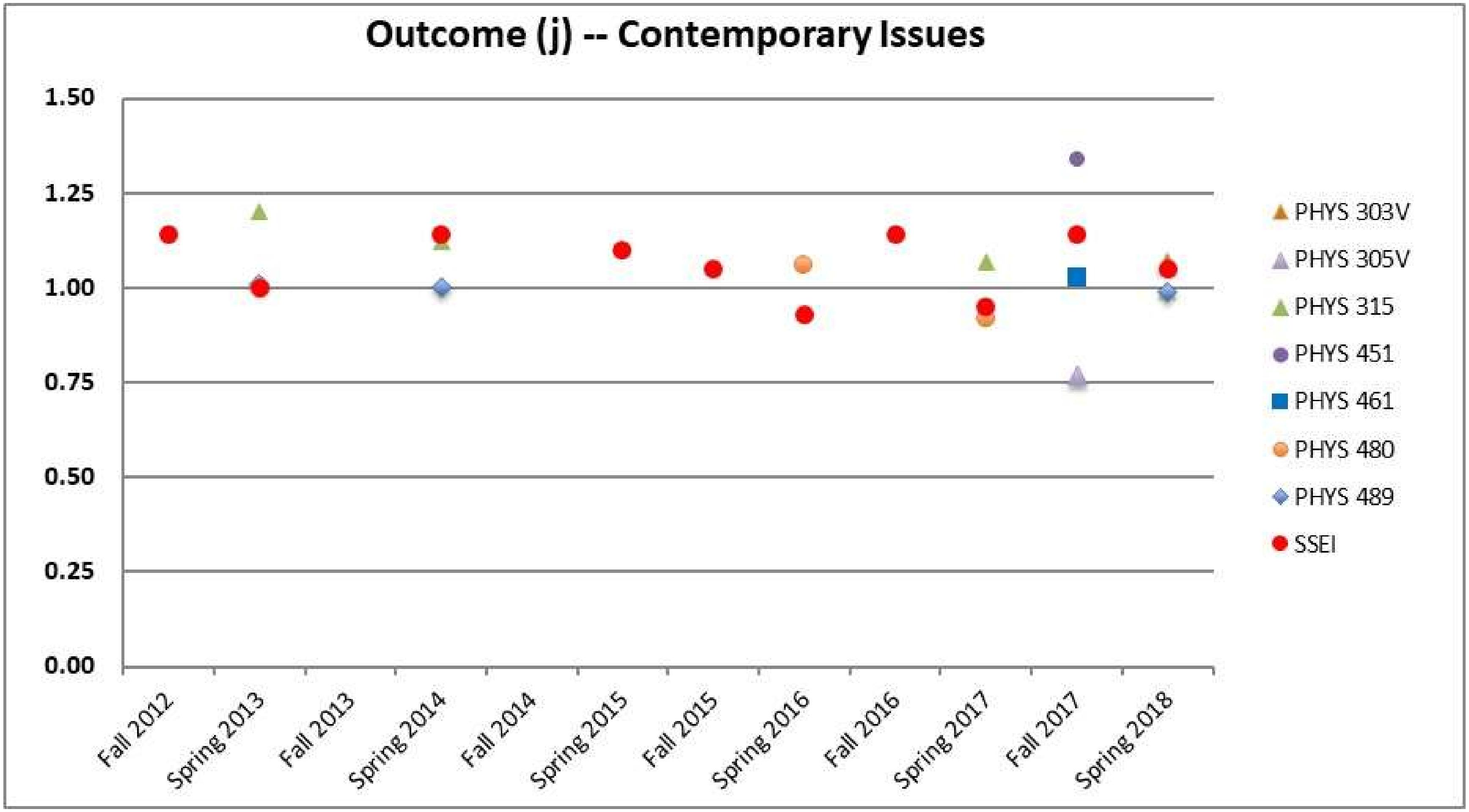
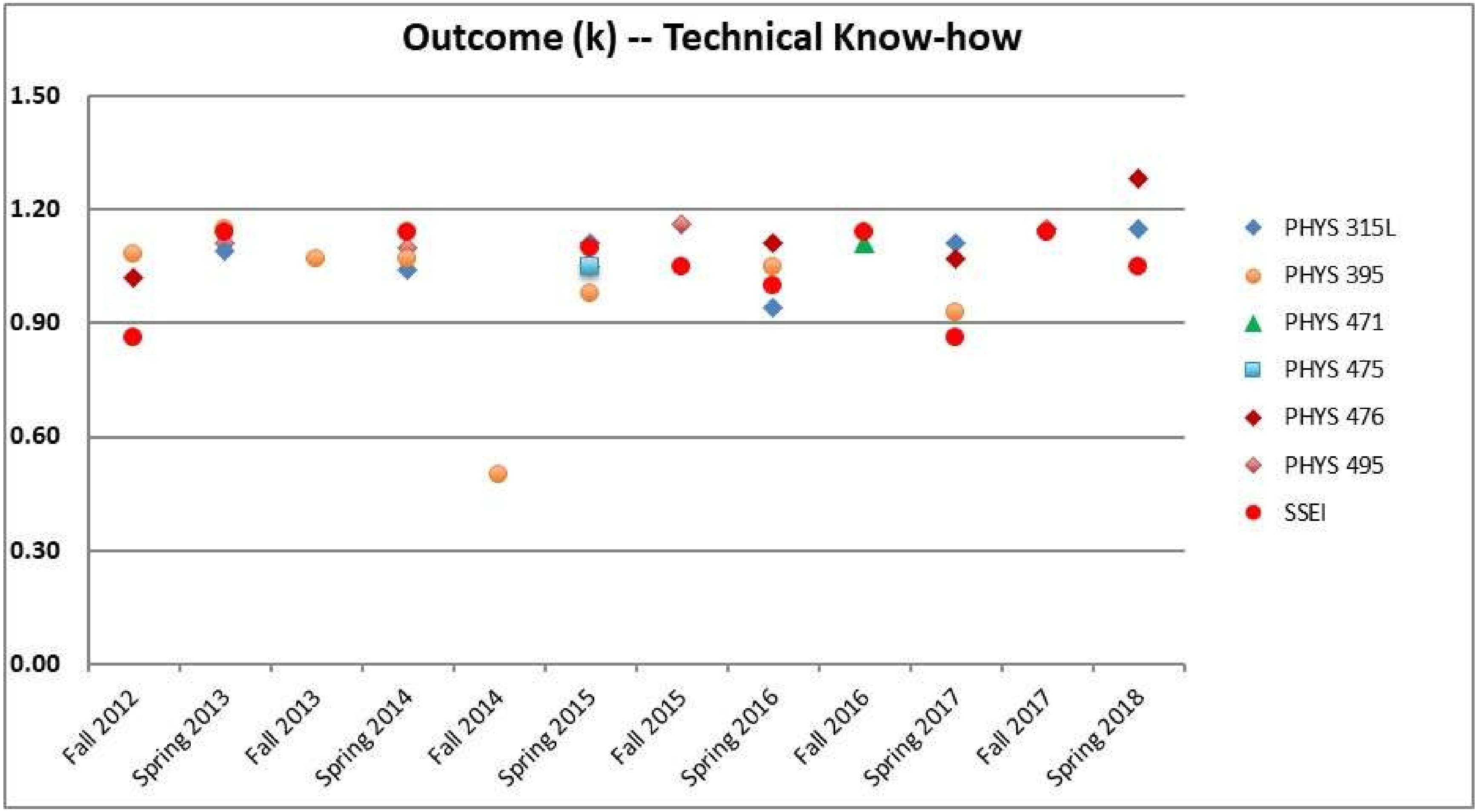


Diagram 4.3.k. *Measured level of achievement (normalized to the stated target) of all courses for Program Outcome (k) since Fall of 2012. Data from Senior Student Exit Interviews (SSEI) are included.*



Summaries of *Program Outcomes* Assessment in *Engineering Departments*

Course Program Outcomes Assessment in the *Department of Mechanical & Aerospace Engineering*

The required AE and ME courses of EP-AE majors, used to assess individual *Program Outcomes (a)-(k)* in the *Department of Mechanical & Aerospace Engineering*, are listed in the assessment matrices in Tables 3.2.b (AE courses) and 3.2.e (ME courses). The assessments are reviewed by a departmental *Outcomes and Assessment Committee* (OAC) once per semester in the *Department of Mechanical & Aerospace Engineering.*

For EP-AE majors, no quantitative data from engineering courses were collected for *Program Outcomes (f) – Professional Responsibility, (h) – Societal Impact* and *Program Outcome (i) – Lifelong Learning*. For EP-ME majors, no quantitative data from engineering courses were collected for *Program Outcomes (h) – Societal Impact* and *Program Outcome (i) – Lifelong Learning*. For *Aerospace Engi*neering and *Mechanical Engineering* majors, meeting these *Program Outcomes* was evidenced by students' written responses of student surveys in the *ME 449 – Senior Seminar course*, administered at the beginning and at the end of the semester. However, this course is not required for our EP-AE or EP-ME majors. Other *Program Outcomes* were measured quantitatively through a variety of assessment tools in relevant ME and AE courses (see Tables 3.2.b and 3.2.e).

The collected materials and data provide the aggregate gauge that all other *Program Outcomes* were found to be mostly satisfied. However, a few individual courses and/or instructors fell short of the expected achievements. For example, there had been some low achievement scores particularly for *Program Outcome (e) – Problem Solving,* which was addressed by adding additional *Problem-Solving Sessions* and *Practice Tests* to some of the ME and AE courses, such as ME 234, ME 236 and ME237. In general, to address shortcomings, the OAC closed loops based on the flowcharts, senior-exist surveys, and input from the department's *Industrial Advisory Committee* (IAC*)*. The OAC meets once every semester to:

- to evaluate the results from the flowchart report from each course instructor and ensure

that the improvement plan is adequate, and

- to determine whether the results from previously proposed plans have been carried out and determine whether the plan's goal has been achieved (i.e., re-assessment).

If the results were deemed inadequate, a new or revised plan may be proposed and carried out in future semesters. Another assessment tool is the exit interviews for graduating mechanical engineering majors, where graduates provide feedback about the quality of instruction and/or course content. Comments directed to specific faculty member's teaching style and/or shortcomings are addressed by the department head with consultation from faculty members during the annual performance evaluation. Finally, the OAC seeks feedback from the IAC, which provides important input on the necessary skills for graduates entering the job market and for success in their careers.

More details on the *Program Outcomes Assessment* through AE courses can be found in the *Aerospace Engineering Self Study Report*, and more details on Program Outcomes Assessment through ME courses *Mechanical Engineering Self Study Report*.

Course Program Outcomes Assessment in the *Department of Electrical & Computer Engineering*

The required EE courses of EP-EE majors, used to assess individual *Program Outcomes (a)-(k)* in the *Department of Electrical & Computer Engineering*, are listed in the assessment matrix in Table 3.2.d. For EP-EE majors, no quantitative data from engineering courses were collected for *Program Outcomes (h) – Societal Impact*. This outcome is assessed in other EE courses that are not required for EP-EE majors.

The *Department of Electrical & Computer Engineering* periodically reviews the achievement of each of the *Program Outcomes*, and changes are made if targets are not met or barely met, often after consultation with the department's *Industrial Advisory Group* (IAG). A few examples of recent changes in EE courses are:

- introduction of metacognition exercises in EE 310 to improve student learning methods - addresses *Program Outcomes (a) – Scientific Expertise* and *(d) – Teamwork.*
- require upper-division electives to include lifelong-learning and ethics exercises – addresses *Program Outcomes (f) – Professional Responsibility*, *(g) – Communication Skills* and *(i) – Lifelong Learning.*
- modified EE4 18 Capstone I to require prototyping of critical subsystems based on *Risk Analysis* - addresses *Program Outcomes (c) – Design Abilities.*

More details on the *Program Outcomes Assessment* through EE courses can be found in the *Electrical Engineering Self Study Report*.

Course Program Outcomes Assessment in the *Department of Chemical & Materials Engineering*

The required CHME courses of EP-CHE majors, used to assess individual *Program Outcomes (a)-(k)* in the *Department of Chemical & Materials Engineering*, are listed in the assessment matrix in Table 3.2.c. A compilation of so-called *Course Assessment Records* (CARs) data is accomplished through use of a form-driven interface located on the website of the *Department of Chemical & Materials Engineering*. This form provides a *Wordpress Access Table* for *Continuous Improvement & Management of Change* database. *Program Outcomes Assessment* data are reviewed by the *Department Head* as it is submitted. Faculty review the CARs reports of:

- courses that are prerequisite to those courses they teach; and
- courses for which the courses they teach are prerequisite.

Findings and trends are discussed at the *Annual Faculty Assessment Meeting* of the *Department of Chemical & Materials Engineering*. CARs assignments for the subsequent year are formed by a committee of the whole at the *Annual Assessment Meeting*. Where the achievement of targets failed, the CAR for that course will be reassessed in the following academic year to assure recommended changes lead to success. Faculty document their assessment responsibilities in the database in real time as the assessments are completed.

More details on the *Program Outcomes Assessment* through CHME courses can be found in the *Chemical Engineering Self Study Report*.

B. Continuous Improvement

Describe how the results of evaluation processes for the student outcomes and any other available information have been used as input in the continuous improvement of the program. Describe the results of any changes (whether or not effective) in those cases where re-assessment of the results *has been completed. Indicate any significant future program improvement plans based upon recent evaluations. Provide a brief rationale for each of these planned changes.*

Continuous improvement of the *EP Program* over the reporting period was initiated by one or more of its stakeholders: the *College of Engineering,* the participating *Engineering Departments,* or the *Department of Physics.* Continuous improvement on the physics side of the *EP Program* has occurred primarily in response to findings of the *Department of Physics* faculty, *EP Program Committee* and/or *EP External Advisory Board* meetings.

In this section, we discuss some of the more important changes that were implemented to improve the quality of the *EP Program* or aspects related to the *EP Program* (closed loops). The areas of improvement can be roughly divided into the following categories: efforts to increase retentions, course re-design & improvements, changes in the course curriculum, and instrumentation & facility upgrades. Every action taken lists the *Program Outcome(s)* that it addresses, and:

a) what observation(s) caused the action,
b) previous approach and proposed changes,
c) activities of implementation, and
d) status of implementation.

The closed loops are not necessarily presented in order of importance.

<u>Efforts to Increase Retention</u>

Introduction of ENGR 100 – *Introduction to Engineering* - addresses *Program Outcomes (c), (d), (e), (f), and (g)* – initiated by the *College of Engineering*

a) The Academic Dean of the College of Engineering felt that the low retention rate among first- and second-year engineering students needed to be addressed.

b) Traditionally, each engineering department has had its own "introductory" engineering course, but there was no uniform format nor any coordination between them.

c) ENGR 100, Introduction to Engineering, is now required of all engineering majors and should be taken by students in their first semester at NMSU. It includes an introduction to the various engineering disciplines, the engineering approach to problem-solving, the design process, teamwork, communication skills, and ethical responsibilities. The goal is to create a sense of purpose in the curriculum, and provide a start on real skill building, from the very first day.

d) The change was fully implemented in Fall 2014. ENGR 100 is now required for all engineering majors, including EP. The EP curricula for all concentrations and associated flowcharts were also adjusted.

***Peer Learning Assistants* (PLAs)** – addresses *Program Outcomes (a), (e), and (k)* – initiated by the *Department of Physics*

a) We sought to increase the level of tutoring provided to Physics and EP students, within the Physics department.

b) Research nationwide has shown that undergraduate tutors and peer learning assistants improve retention. We introduced a formal program for recruiting and training so-called Peer Learning Assistants (PLAs).

c) *Supported with funds from the Provost, the President, and departmental resources, in FY 16/17 nine undergraduate tutors were hired at a cost of $4200. Numbers for FY 15/16 were similar. Additional students in the program are hired as tutors by other organizations on campus, such as the Math Success Center, the College of Engineering, and others.*

d) *Unfortunately, the funds for this program from the Provost's office dried up due to budgetary reductions in the past years. But we hope to revive this program again in the future.*

Introduction of Additional Supplemental Instruction Courses – addresses *Program Outcomes (a) and (e)* – initiated by the *Department of Physics*

a) *We continue to note student difficulties in 200-level lecture courses, which affects learning and our retention rate.*

b) *We first introduced "supplemental instruction" in Fall 2012, for just one course, PHYS 213 Mechanics, in the form of a 1-credit work session focusing on problem-solving strategies.*

c) *Now we have supplemental instruction courses for PHYS 213, 214, 215, 216, 217 and 315. These are not required courses but we encourage students to take them to improve their problem-solving skills.*

d) *All supplemental instruction courses have been in place starting Fall 2017.*

MATH tutoring by a Physics Teaching Assistant – addresses *Program Outcomes (a) and (e)* – initiated by the *Department of Physics*

a) *Some incoming freshmen struggle with the Introductory Calculus, MATH 191 or MATH 192, sequence, or don't have the high-school preparation to enroll in that sequence. This affects whether incoming students can enroll into introductory physics courses.*

b) *While the Math Department and the College of Arts & Sciences offer their own math tutoring, it is beneficial to bring students into the department as early as possible. This ensures that EP students feel a sense of belonging to the program.*

c) *Using departmental funds, the Department of Physics supports a Physics Teaching Assistant, who can provide math tutoring free of charge for incoming students in their freshmen and sophomore year.*

d) *Support of a Physics TA for math tutoring started in Fall of 2016 and is continuing.*

Support for activities of the *Society of Engineering and Physics* (SEPh) – addresses *Program Outcomes (f), (h), (i), and (j)* – initiated by the *Department of Physics*

a) *It is important to have intramural student groups that build relationships among students, promote civil teamwork, and improve retention.*

b) *SEPh was formed in 2010 to address a concern of our EP students that they didn't have their own student group; they felt the local Society of Physics Students (SPS) chapter did not serve their needs.*

c) *The level of activity in SEPh depends somewhat on the student membership. Recently they have been very active and we have supported their restoration of an old telescope (2016) and the Department's Foucault pendulum (2017), and the construction of a 3D printer (2017).*

d) *The Department of Physics supported these efforts via purchases of equipment with departmental funds.*

Support for undergraduates to attend scientific conferences – addresses *Program Outcomes (f), (g), (h), and (i)* – initiated by the *Department of Physics*

a) *This is part of our continuing effort to expose undergraduates to up-to-date research.*
b) *To raise interest in physics overall, especially the idea of research and careers in physics, the department supports students attending physics conferences financially, usually with $150 per student and conference. Together with support from other sources, students are usually able to cover all costs of attending a regional physics or applied physics conference.*
c) *A large contingent of NMSU students attended the APS Four Corners meeting in Tempe AZ in Fall 2015. In the fall of 2016, the department hosted the Section Meeting of the Four Corners and Texas Sections of the American Physical Society (APS) in Las Cruces, where students in our program could interact with students and professors from other institutions in the region. To increase the retention of women, the department promotes the annual APS Conferences for Undergraduate Women in Physics, especially to our freshmen and sophomores. Several of our students attend each year. In Fall of 2017, a group of NMSU students attended the APS Four Corners meeting in Ft. Collins CO.*
d) *This is a continuing program.*

Increased access to scholarships – addresses *Program Outcomes (f) and (i)* – initiated by the *Department of Physics*

a) *Previously, the EP program did not have the same access to College of Engineering scholarships as other Engineering majors.*
b) *The Physics Department has extensive endowments, but with increased enrollment between the Physics and Engineering Physics programs we were unable to serve all our students. The College of Engineering has a scholarship committee but our program was not represented on this committee.*
c) *Dr. Heinz Nakotte now serves on the College of Engineering Scholarship committee and as a result several of our students have received scholarships directly from the College of Engineering. Also, independently, the Physics Department started its own Engineering Physics Scholarship.*
d) *Dr. Nakotte started to serve on this committee in 2016. The EP Scholarship was also started in 2016.*

<u>**Course Re-Design & Improvements**</u>

Introduction of MatLab into PHYS 315L and other elective courses – addresses *Program Outcomes (e) and (k)* – initiated by the *Department of Physics*

a) *There had been a longstanding disconnect between the computational instruction in the College of Engineering (largely MatLab-based) and that in the Physics department (either Fortran-based or lacking/omitted).*
b) *The PHYS 150 Elementary Computational Physics course is required of physics majors only; Engineering Physics majors usually get introductory computational training in*

their respective engineering departments, and this is increasingly MatLab-based. The Department of Physics did not have any MatLab capabilities earlier.

c) *The Physics Department has purchased a 25-seat license for MatLab for use in the PHYS 315L - Experimental Modern Physics and in the physics Computer Laboratory for use in other courses that have computational projects (PHYS 476 Computational Physics for example).*
d) *We first employed MatLab in the Physics department in Fall 2014. Since Fall of 2017, the University has purchased a campus license for MatLab, which is provided free-of-charge to the program. MatLab is now in regular use among our Physics and Engineering Physics students, and in the PHYS 150, 315L, and 476 classes.*

Continual modification of *PHYS 395 Intermediate Mathematical Methods of Physics* course to meet student needs -- addresses *Program Outcomes (a), (e), and (k)* – initiated by the *Department of Physics*

a) *We introduced the PHYS 395 course in Spring 2010 to give our students additional mathematical training as they made the transition from the elementary use of mathematical tools in the 200-level physics courses to the more advanced level required in 400-level courses.*
b) *After a few semesters we learned the topics and the level of instruction that was of maximum concern to the students and of maximum need in the 400-level physics sequence.*
c) *Adjustments were made in the ordering and emphasis of the topics: vector calculus, complex numbers, linear algebra, and differential equations.*
d) *We have settled on offering this course in the fall of the junior year, and we ask the instructor to present material on vector calculus first since this is the first material the students are likely to see in the 400-level courses they typically take that year.*

Increased faculty involvement in 200-level instructional laboratory courses – addresses *Program Outcome (b)* – initiated by the *Department of Physics*

a) *Faculty were not strongly involved in the 200-level instructional laboratory courses and the department began to feel that these courses were not moving forward.*
b) *For many years the "instructor of record" of the 200-level introductory lab courses (213L, 214L, 215L, and 216L) was the physics department laboratory coordinator, a staff member with a Master's or Ph.D. in physics. This staff member supervised undergraduate and graduate students to setup and operate the lab courses. The development of these courses came to a halt and the reporting required for continual improvement was irregular.*
c) *When the lab coordinator resigned and went to another institution, we took the opportunity to reform the operation of these labs. A regular faculty member will be the instructor of record and will also be the TA of one of the lab sections.*
d) *This reformed program started in Fall 2016.*

Introduction of new experiments in the 200-level instructional lab courses – addresses *Program Outcome (b)* – initiated by the *Department of Physics*

a) *It is desired to improve the pedagogical function of the experiments in the 213L, 214L, 215L, and 216L lab courses.*
b) *Many of the same experiments were done year after year, while new technology allows for better experiments that more directly illustrate the physics concepts of interest.*
c) *We purchased new experiments to educate the students in Ballistic Motion, Archimedes Law, Oscilloscope Function, and RC Circuits. Also, the scheduling of these labs was modified.*
d) *These changes took place starting in Fall 2016.*

Increasing the engineering content in PHYS 461 & 462 – addresses *Program Outcome (e)* and *(j)* – initiated by the *Department of Physic*

a) *The courses on Intermediate Electricity & Magnetism I and II, PHYS 461 and PHYS 462, are required for all physics and most of the EP majors. Like many other physics programs, we use Griffiths' textbook on Introduction to Electrodynamics, which is established as a standard textbook for these courses. The main mode of delivery in Griffiths' textbook is in terms of fundamental physics of electrodynamics, with only few select (and more traditional) engineering applications. In 2016, some concerns were raised as to whether students taking these two courses get sufficient exposure to modern engineering concepts in that field*.
b) *The instructors agreed to increase the engineering content in those two courses either by including engineering-based/oriented homework problems or requiring engineering-based/oriented project reports.*
c) *Aside from the fundamental Griffiths' textbook, the course instructors have introduced Balanis' textbook on Engineering Electrodynamics as a second recommended read to these courses. This textbook is used for homework problems and projects with significant engineering components.*
d) *Supplementary engineering components were introduced starting in Spring of 2017, and it will continue to be a required component in PHYS 461 and 462.*

<u>Changes in the Course Curriculum</u>

Plans for an Engineering-Wide Capstone Course – addresses *Program Outcomes (c), (d), and (e)* – initiated by the *Department of Physics* and the *Department of Aerospace & Mechanical Engineering*

a) *The EP Program Committee has long noted the difficulties presented by the various capstone courses in the various engineering departments. While EP students for the Aerospace, Electrical and Mechanical Concentrations fulfill all pre-requisite requirements to participate in the engineering capstones of their respective concentrations, none of the EP students would fulfill the pre-requisite requirements to participate in a capstone in another engineering department. A frequent observation is that EP students of different concentrations develop interest to participate in the same common capstone, regardless of their individual concentrations, which was not possible with the capstone system that was in place. The situation was further complicated for EP students with the Chemical Concentration, who would need to take an additional 3 courses to satisfy the capstone pre-requisites in the Department of Chemical & Materials Engineering.*

b) *Traditionally, each engineering department had their own Capstone Course, but there was no uniform protocol or set of prerequisite courses. This presented a difficulty for interdisciplinary student teams – which capstone course should they sign up for, and how will they meet the prerequisites?*

c) *A proposal was developed by Dr. Heinz Nakotte (Department of Physics) and Dr. Gabe Garcia (Department of Mechanical & Aerospace Engineering), to offer a single engineering-wide capstone course with an ENGR prefix that would be open to all engineering students. A precedent was set with the introduction of ENGR 100. Students of any engineering discipline could enroll in the engineering-wide capstone as long the students fulfill the pre-requisite requirements for a capstone in their engineering major; EP pre-requisites would be considered satisfied with the students taking the Modern Physics Laboratory, PHYS315L. The idea was proposed to the College of Engineering and all its departments, and there seemed to be broad support across all entities. One advantage of such an engineering-wide capstone is the possibility of true interdisciplinary capstone.*

d) *A pilot project (coordination between two separate Mini-Baja Capstones in Mechanical and Electrical Engineering) was started in Fall 2017 with the goal to see whether interdisciplinary and cross-departmental capstones could work. In Spring of 2018, the College of Engineering appointed Dr. Garcia as the Interim Director of the Aggie Engineering Capstone Design Program, which is in charge to develop and formalize such Engineering-Wide Capstones for future years.*

Introduction of Additional Advanced Labs in Physics – addresses *Program Outcomes (b), (c), (d), (f), (g), and (k)* – initiated by the *Department of Physics*

a) *For several semesters recently, the Physics Department only offered a single 400-level advanced laboratory course, PHYS 475; students commented on the lack of choices.*

b) *In the more distant past there had been optics and nuclear physics lab courses. The optics lab course had fallen by the wayside due to the retirement of one of our faculty members, and the nuclear physics lab course was temporarily combined into the curriculum of the PHYS 475 course.*

c) *It was decided to restore the PHYS 493 Experimental Nuclear Physics and PHYS 471 Modern Experimental Optics courses. Increases in enrollment meant that these courses would be viable, and this would provide students with more choices and more flexibility in scheduling.*

d) *The PHYS 493 course started up again in Fall 2013, PHYS 471 was offered in Fall 2016, and both labs will be offered in Fall of 2018.*

Introduction of additional upper-division elective courses – addresses *Program Outcomes (a), (e), and (k)* – initiated by the *Department of Physics*

a) *Some of the EP curricula include upper-division "technical electives" but students have complained about a lack of useful choices.*

b) *The purpose of the technical electives is to allow the students to round out their studies by exploring topics in which they have an interest. Students have expressed interest in areas where no existing course is relevant.*

c) We introduced several "one-off" courses based on expressed student interest. Some recent examples are: (1) an "Arduino" electronics course, where the students built circuits centered on these cheap miniature processors; (2) an "X-ray" course where the students learned the physics that can be explored using x-rays as a probe; (3) a course in "scattering theory" that went beyond what was usually taught in the quantum mechanics, electromagnetism, and classical mechanics courses.

d) None of these courses were intended to be permanent additions to the catalog, and were taught under "special studies" course numbers. Instead, we will continue communicate with the students and try to respond to their needs as best we can.

Evolution of engineering curricula for all four EP – addresses *all Program Outcomes* – initiated by participating *Engineering Departments*

a) No curriculum can be static and serve the changing needs of students. When the University changed its minimum credit-hour requirements from 128 to 120, all engineering programs explored whether they would be able to adjust their individual curricula and course offering such that it would not jeopardize their accreditation.

b) While most engineering programs at NMSU, including EP, decided that they could not transition to 120 credits for their major, all four corresponding programs in the College of Engineering (Mechanical, Electrical, Chemical and Aerospace) have made significant changes to their major curricula and course offerings as a result. These changes affected the EP program as well.

c) The actual changes made are too numerous to list in this format; details can be found in the individual SSRs of the affiliated engineering programs. More relevant is the process whereby we meet with representatives of the four corresponding engineering programs to learn the motivations behind their changes and how we can best respond. We have always worked to keep the number of credit hours as close to 128 as possible; we have not yet seen a way to get down to 120 credit hours; we await the outcome of an ongoing state-wide reform of the Common Core system.

d) The new Common Core system should be ready within a year, and at that point we will know how to adjust our curriculum to reduce the number of hours to be as close to 120 as we can.

Support for "experiential learning" from the Board of Regents – addresses *Program Outcomes (f), (h), (i), and (j)* – with participation of Dr. Zollner from the *Department of Physics*

a) The NMSU Board of Regents expressed a desire that all students have a defined "experiential learning" opportunity during their time at NMSU.

b) A bill concerning this topic was put before the NMSU Faculty Senate in Fall 2017.

c) This does not actually drive any change in our program, because our students already have experiential learning opportunities in the advanced laboratories and engineering capstone projects.

d) We look forward to demonstrating that our students have always had these opportunities.

<u>**Instrumentation & Facility Upgrades**</u>

Use of *Arts & Sciences Equipment Funds* and *Engineering Student Technology Fees*, to improve instructional laboratory equipment – addresses *Program Outcomes (b), (c), and (e)* –

initiated by the *Department of Physics* with help from the *Colleges of Arts & Sciences* and the *College of Engineering*

a) *There is always a need to maintain, repair, or replace instructional lab equipment that is faulty or out-of-date.*
b) *Part of our assessment program for the instructional labs is to identify equipment that needs to be replaced. Usually the replacement should be motivated by a desire to improve the pedagogical aspect of the laboratory, rather than by a search to find an identical item.*
c) *Both, Arts & Sciences instructional funds and Engineering student fees, were used to fund purchases of computers, flat-screen monitors, sensor interfaces, oscilloscopes, power supplies, metals samples for Hall Effect measurements, neon tubes for the Franck-Hertz experiment, miniature UV-VIS-IR spectrometers, precision voltmeters and ammeters, and a state-of-the art high-purity germanium crystal gamma-ray detector. This fee also pays user fees for high tech equipment (x-ray diffractometer, electron and atomic force microscopes) that advanced laboratory students use.*
d) *These items are in current use in the introductory 200-level labs, the PHYS 315L lab, and the Advanced Physics Labs.*

Card-reader access to *Department of Physics* facilities after hours – addresses *Program Outcomes (f)* - initiated by the *Department of Physics*

a) *Most students prefer having access to departmental facilities, such as the Computer Lab, particularly when working on projects as a team.*
b) *In general, students' time during regular working hours is limited because of courses and/or labs, i.e. teams working on joint projects prefer access to departmental facilities after hours, which are often the only common times where all team members can meet.*
c) *All EP students in good standing will be provided with key card access to some of the departmental facilities, such as the Physics Computer room. Students who have completed all necessary safety training may be provided with access to some experimental (research) facilities as well, although a strict 2-person rule in enforced for after-hours work.*
d) *Access permissions for undergraduate students to some of the departmental facilities was implemented a few years ago, and they continue to be granted based on need.*

C. Additional Information

Copies of any of the assessment instruments or materials referenced in 4.A and 4.B must be available for review at the time of the visit. Other information such as minutes from meetings where the assessment results were evaluated and where recommendations for action were made could also be included.

Most of the material will be available in electronic form. In addition, hard copies of display materials are presented in four different sets of folders and binders: the *'Maroon' Instructor's*, the *'White' Course*, the *'Blue' Program Outcomes* and the *'Black' Educational Objectives Notebooks*. The contents of the different binders are listed *in Appendix E – Supplementary Documents*. summarized below. Textbooks, lab manuals and other course-related materials are also available during the time of the ABET review visit.