UNIT REPORT

Physics - Institutional Effectiveness Final Annual Report 2019

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Definition of Unit

Academic Curriculum Map

Reporting Year: 2018-2019

Providing Department: Physics

Department/Unit Contact: Stephen Robinson

Mission/Vision/Goal Statement:

Support for core goals and learning outcomes in the program of study for a B.S. in Physics.

		Goals/Learning Outcomes					
Course	Title	Physics knowledge	Analytical skills	Laboratory skills	Communication skills	Computer skills	Research experience
PHYS 1137	Frontiers of Physics	X					
PHYS 2110	Calculus-based Physics I w/lab.	X	X	X			
PHYS 2120	Calculus-based Physics II w/lab	X	X	X			
PHYS 2420	Modern Physics	X	X		X	X	
PHYS 2920	Mathematical Physics		X		X	X	
PHYS 3610	Classical Mechanics	X	X		X	X	
PHYS 4610	Classical Elec. & Mag. I	X	X		X	X	
PHYS 4620	Classical Elec. & Mag. II	X	X		X	X	
PHYS 3120	Statistical Thermal Physics	X	X		X	X	
PHYS 3810	Quantum Mechanics I	X	X		X	X	
PHYS 3820	Quantum Mechanics II	X	X		X	X	
PHYS 4710/ PHYS 4711	Advanced Experimental Physics	X	X	X	X	X	
PHYS 4130	Computational Physics		X		X	X	
PHYS 4130	Research Planning	X	X	X	X	X	X
PHYS 4140	Research	X	X	X	X	X	X

Physics Department Mission Statement

Reporting Year:

Providing Department: Physics

Department/Unit Contact: Steve Robinson

Mission/Vision/Goal Statement:

The mission statement for the TTU Department of Physics is to promote the learning of physics through effective teaching, research, and public service. Such learning opportunities are provided to students of all disciplines, in support of the mission of the University.

The department addresses this mission through two programs;
i) a coherent program of study leading to a B.S. in Physics, and
ii) a service program that provides courses in physics and astronomy that are requirements for other degree programs or are used by students to fulfill general education science requirements.

Goal/Objective/Outcome

Learning Outcome 1 - Diagnostic Test

Define Goal:

Students completing introductory physics courses will demonstrate increased understanding of certain basic concepts by achieving an average normalized gain score of at least 40% on a standardized conceptual diagnostic test.

Intended Outcomes / Objectives:

Learning Outcome 2 - Major Field Test

Define Goal:

Students graduating in physics will demonstrate an understanding of the principles and foundations of physics by having graduates score, on average, at or above the 75^{th} percentile on the ETS Major Field Test in Physics.

Intended Outcomes / Objectives:

Learning Outcome 3 - Experimental Skills

Define Goal:

Students graduating in physics will demonstrate the skills and techniques necessary to engage in experimental investigation, by having at least 75% of students achieve a grade of C or better in the capstone senior lab course (PHYS 4710 or PHYS 4711).

Intended Outcomes / Objectives:

Learning Outcome 4 - Oral Presentation

Define Goal:

Students graduating in physics will demonstrate the ability to communicate their understanding orally, as judged by a faculty committee who will report on oral presentations in the capstone senior lab course (PHYS 4710).

Intended Outcomes / Objectives:

Learning Outcome 5 - Technological Tools

Define Goal:

Students graduating in physics will have received an introduction to the technological tools appropriate to physics and related disciplines, as reported by graduating physics majors in exit interviews and by alumni in surveys conducted periodically.

Intended Outcomes / Objectives:

Learning Outcome 6 - Career Preparation

Define Goal:

Students graduating in physics will agree that the program gave them sufficient preparation to continue to graduate school or obtain suitable employment, as reported by graduating physics majors in exit interviews and by alumni in

surveys conducted approximately every five years.

Intended Outcomes / Objectives:

Learning Outcome 7 - Development of Research Skills

Define Goal:

Students graduating in physics will demonstrate the skills and techniques needed to engage in planning and carrying out basic or applied research by having at least 75% of students achieve a grade of C or better in the PHYS 4730 (Research Planning) and PHYS 4740 (Research) courses taken as seniors. When applicable, during exit interviews, they will also be asked about the value of their research experiences as undergraduates in the department.

Intended Outcomes / Objectives:

Program Goal 1 - Number of Majors

Define Goal:

Increase the number of physics majors (as determined at the beginning of each Fall Semester) to a 5-year average of 50. This will be done through continued efforts at recruitment and retention.

Intended Outcomes / Objectives:

Approved - Nat

Program Goal 2 - STEM Center

Define Goal:

Contribute to the mission of the Millard Oakley Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM), by encouraging faculty members and physics students to become actively involved in the center.

Intended Outcomes / Objectives:

Program Goal 3 - Teaching Reflection

Define Goal:

Encourage faculty to reflect on their own teaching by making them aware of effective pedagogical developments coming from the physics education research community that may be relevant to their own classes.

Intended Outcomes / Objectives:

Program Goal 4 - Undergraduate Research Opportunities

Define Goal:

The department will maximize opportunities for physics majors to gain experience in basic or applied research by encouraging their participation in the research programs of departmental faculty, or in summer research programs at other institutions.

Intended Outcomes / Objectives:

Assessment Tools

Tool 1 - Count Physics Majors

Goal/ Outcome/ Objective: Program Goal 1

Type of Tool: Other

Frequency of Assessment: Beginning of every fall semester

Rationale:

At the beginning of each fall semester a count is made of the number of the total number of enrolled students who have Physics declared as a major. Because of the small numbers involved, trends are tracked using an average of the current year plus the previous four years.

Tool 10 - Exit Interviews

Goal/ Outcome/ Objective: Learning Outcomes 5, 6, 7

Type of Tool: Other

Frequency of Assessment: As necessary for graduating seniors

Rationale:

Because of the delay in feedback via alumni surveys, we also address these student learning outcomes with students who are getting ready to graduate from the program. While these students do not have the benefit of post-program experience, they do have a fresher recollection of their TTU experiences and so can provide valuable feedback on some elements of the program. The department chair already conducts a confidential exit interview with each graduating physics major. These interviews explicitly address how well prepared each student feels for their next career step, including their preparation in the use of technological tools and development of research skills.

Tool 11 - PHYS 4730 (Research Planning) and PHYS 4740 (Research)

Goal/ Outcome/ Objective: Learning Objective 7

Type of Tool: Capstone Project

Frequency of Assessment: Annually

Rationale:

All physics majors must take these two senior level research courses. To be successful in these courses students must create a detailed research plan and present it both in written and oral formats (PHYS 4730). They must then conduct the planned research and again present the results in written and oral formats (PHYS 4740). Each year the department will use the grades attained in these courses to judge students' competence in planning and conducting research.

Tool 2 - Examine STEM Center Involvement

Goal/ Outcome/ Objective: Program Goal 2

Type of Tool: Survey

Frequency of Assessment: End of each academic year

Rationale:

At the end of each academic year, a count is made of the number of actual or proposed projects,programs, and outreach events in which members of the Physics faculty and physics undergraduates were jointly involved with the Millard Oakley Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM).

Tool 3 - Research Involvement and Skills Development

Goal/ Outcome/ Objective: Program Goal 4 and Learning Objective 7

Type of Tool: Other

Frequency of Assessment: End of each academic year

Rationale:

The department will keep a record of student participation in the research of department faculty members and in specialized summer research programs for undergraduates at other institutions. (Note: since almost all such experiences must necessarily take place during the summer it is impossible to ensure that all students will take advantage of such opportunities. However, the department will encourage such participation as actively as possible.)

Tool 4 - Teaching Developments

Goal/ Outcome/ Objective: Program Goal 4

Type of Tool:

Frequency of Assessment: End of each academic year

Rationale:

In their annual reports faculty members will be asked to comment on their awareness of new pedagogical developments and whether they have tried to implement them in their own teaching.

Tool 5 - Video of Classes

Goal/ Outcome/ Objective: Program Goal 4

Type of Tool:

Frequency of Assessment: Once per academic year

Rationale:

Once each academic year, every faculty member is video-taped teaching a class. The chair uses these video-tapes to assess a faculty member's teaching in terms of the implementation of effective pedagogy. The tapes are also made available to the faculty members concerned to facilitate reflection on their own teaching.

Tool 6 - Force Concept Inventory

Goal/ Outcome/ Objective: Learning Outcome 1

Type of Tool: Other

Frequency of Assessment: Beginning and end of each semester

Rationale:

This nationally recognized diagnostic test of basic conceptual understanding is administered to all students at the beginning of both PHYS 2010 and PHYS 2110 courses, and then again after the relevant material has been covered. The gain score, used to judge improvement in understanding, is a measure of the actual improvement in performance after instruction, versus the maximum possible improvement.

Tool 7 - Major Field Test

Goal/ Outcome/ Objective: Learning Outcome 2

Type of Tool: Exit Exam

Frequency of Assessment: When necessary for graduating seniors

Rationale:

All physics graduates will take the ETS Major Field Test in Physics during their final semester at TTU.

Tool 8 - PHYS 4710/4711 Capstone Course

Goal/ Outcome/ Objective: Learning Outcomes 3 & 4

Type of Tool: Capstone Project

Frequency of Assessment: When necessary for graduating seniors

Rationale:

All physics majors take a senior lab course, either PHYS 4710 (4 cr) or PHYS 4711 (2 cr). To be successful in this course students must synthesize many skills learned in their academic careers to date. They must engage in scientific investigation by planning and carrying out experiments, and they must use their physics knowledge to guide them and to interpret their results. They must also submit written reports of all their investigations and make a public oral presentation of one project at the end of the semester. Faculty present at these presentations will submit a report on them. A written summary of these reports, together with an assessment as to whether a particular student has met this outcome, will be compiled by the faculty member teaching the course, and placed in the student's file.

Tool 9 - Alumni Survey

Goal/ Outcome/ Objective: Learning Outcomes 5 & 6

Type of Tool: Survey

Frequency of Assessment: Approximately every five years

Rationale:

Because of the low number of physics graduates, these surveys are administered to department alumni on an approximate 5-year cycle. Among the questions asked are how well graduates felt the TTU physics program prepared them for their chosen career path, and how effectively they were introduced to appropriate technological tools. (The most recent results available are from the survey conducted in Fall 2014 in conjunction with the department's scheduled

academic audit.)

Attached Files

TTU Physics Alumni Survey

Results

Result 1 - Number of Physics Majors

Goal/Objective/Outcome Number: Program Goal 1

Results:

The number of declared physics majors at the start of the Fall 2017 semester was 30, which is a slight increase from the previous year. However, we still have a long way to go to reach our goal of a five-year average 50 majors.

Attachments:

Result 10 - Exit Interviews

Goal/Objective/Outcome Number: Learning Objectives 5, 6, 7

Results:

In interviews conducted just before graduation four seniors expressed general satisfaction with their preparation at TTU. Addressing the department goal of giving students a good grounding in computational techniques, all said their exposure was valuable, though two would have liked more practice in the use of commercial software packages. Addressing the department goal of developing students' research skills, all reported that their experiences within the department had been invaluable in this area, but one expressed a desire for more mentoring in the skills needed.

Attachments:

Result 2 - STEM Center Involvement

Goal/Objective/Outcome Number: Program Goal 2

Results:

Physics faculty involvement in projects and programs associated with the Millard Oakley STEM Center (MOSC) has continued at a high level. Again, one faculty member taught a complete course using the MOSC facilities. Four faculty members were also engaged with the Center in other ways. Two were PIs on separate grants administered by MOSC and three physics faculty and approximately ten students were involved in several different public outreach events offered by MOSC.

Attachments:

Result 3 - Student Research Involvement

Goal/Objective/Outcome Number: Program Goal 4.

Results:

During this year a total of twenty individual undergraduate students participated in research activities of various types with department faculty members. In addition one graduate student in the College of Education was mentored by two physics faculty members.

Attachments:

Result 4 - Teaching Developments

Goal/Objective/Outcome Number: Program Goal 4

Results:

During this year several developments in instruction occurred in the department:

- Materials for the LEAP format of the PHYS 2020 course were finalized.
- Two faculty members continued developing a 'flipped' class format for the PHYS 2120 class.
- An online version of PHYS 2110 was planned and developed, to be delivered for the first time in Fall 2019.
- The Frontiers of Physics freshman seminar class (PHYS 1173) was taught for the first time.
- A new Observational Astronomy (ASTR 3100) was proposed and will be be delivered for the first time in Fall 2019.
- A program for a minor in Astronomy was approved by the University.

Attachments:

Result 5 - Video of Classes

Goal/Objective/Outcome Number: Program Goal 4

Results:

No classroom video was recorded again this year because of time pressure imposed by various administrative functions. Since we have another tool that addresses Program Goal 4, we are considering abandoning this particular measure.

Attachments:

Result 6 - Force Concept Inventory (FCI)

Goal/Objective/Outcome Number: Learning Outcome 1

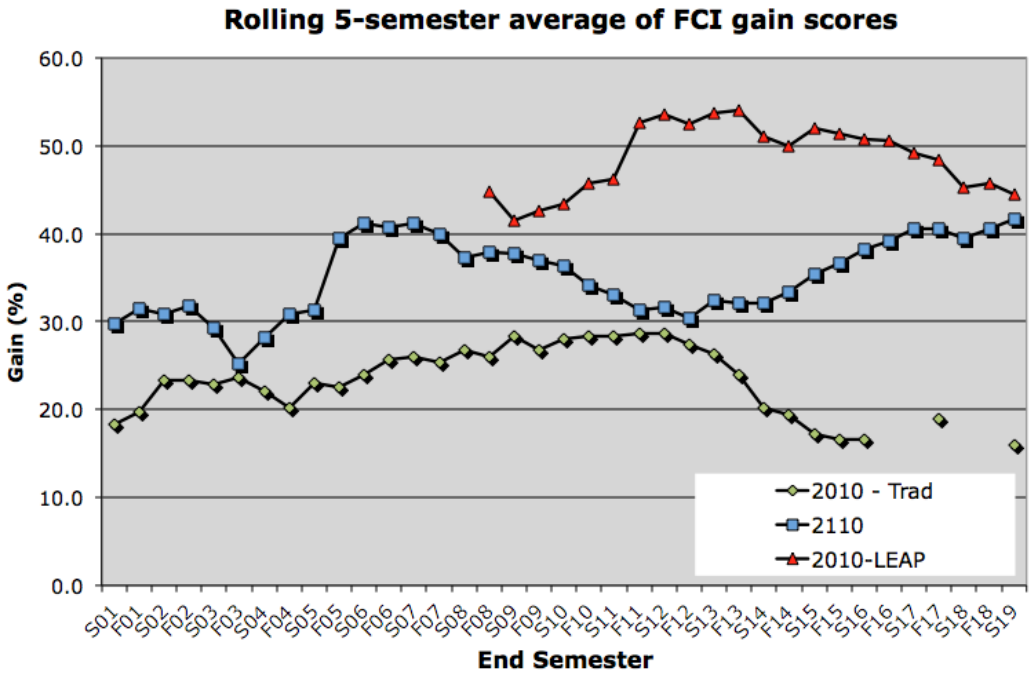
Results:

In the 2018/19 academic year 7 of 9 sections of PHYS 2110 achieved the goal of a normalized gain of 40% or more. The average gain of all 9 sections was approximately 44%. At 41.6% the rolling 5-semester average gain is the highest it has been since we have been keeping records!

In PHYS 2010 the 6 sections taught using the guided-inquiry LEAP curriculum had an average gain of 44%. While this surpasses the goal of 40%, this average is the lowest for several years. This relatively disappointing result is mainly due to one of the individual spring sections having an unusually low gain of 25%. The reason for this is not clear.

The one section of PHYS 2010 taught in the more traditional manner again showed a low gain of less that 20%, reconfirming that the LEAP format produces significantly enhanced student learning.

The graph below shows the rolling 5 semester average of FCI gains in relevant courses and a fuller report on a continuing longitudinal study is attached.



Attachments: Attached Files

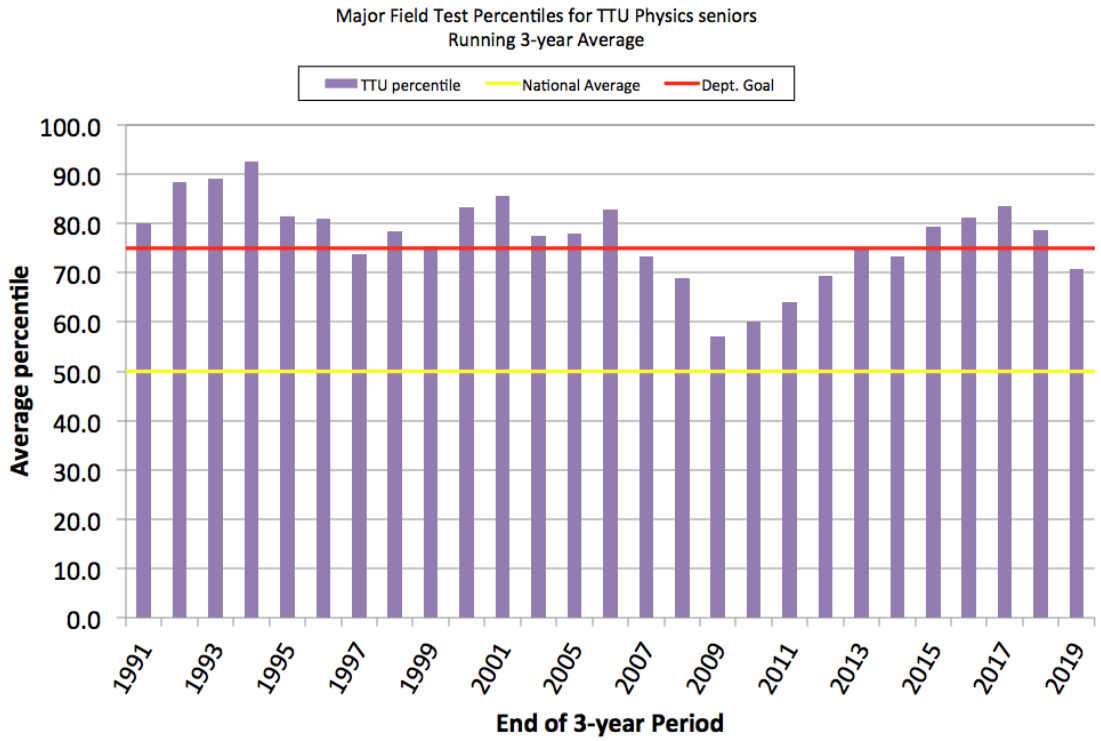
FCI_report_2019.pdf

Result 7 - Major Field Test

Goal/Objective/Outcome Number: Learning Outcome 2

Results:

Five students took the Major Field Test in Physics this year, with an average percentile ranking of 69%. Our three year average percentile now stands at 71%, which has slipped below the department goal of an average of the 75th percentile for the first time in 5 years.



A breakdown of MFT results suggests students are weaker in the areas of Optics/Waves and Thermodynamics. Over the coming year, the department will discuss a course of action to address this weakness.

Attachments:

Result 8 - Capstone Course

Goal/Objective/Outcome Number: Student Learning Outcomes 3 & 4

Results:

Three physics majors took either the PHYS 4710 or 4711 course this year, only two of who received a grade of C or above. However, all three were judged by the faculty to have made acceptable oral presentations.

Attachments:

Result 9 - Alumni Survey

Goal/Objective/Outcome Number: Learning Outcomes 5 & 6

Results:

Due to the low numbers of graduates we only conduct this survey every 5 years. The most recent survey was conducted this year in conjunction with our program review. A full report is attached, but significant results are:

- TTU physics students continue to be highly satisfied with the program and the level of preparation they receive for their future careers.
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Attachments: Attached Files

alum_survey_report_2019.pdf

Results 11 - Research Courses

Goal/Objective/Outcome Number: Learning Objective 7

Results:

In their second implementation, three students completed these course. All achieved a grade of C or higher, thus demonstrating their attainment of the required skills and in planning and carrying out research.

Attachments:

Modifications and Continuing Improvement to Goals/Objectives/Outcomes

Change Related to Learning Outcome 1 and Program Goal 3 - Raising the FCI gain goal

Goal/Objective/Outcome Number: Program Goal 3 and Learning Outcome 1

Program Changes and Actions due to Results:

For many years the department goal for the Force Concept Inventory (Tool 6) administered as a pre-/post-test in PHYS 2010 and PHYS 2110 has been to achieve a gain of at least 40%. With the development of the LEAP curriculum for PHYS 2010 and the more widespread adoption of student-centered instructional strategies in PHYS 2110 we have now achieved this goal in both courses (Result 6). Therefore, for the coming year we will raise this goal to a gain of 45%.

Link to Assessment:

Detailed feedback on FCI results (Tool 6, Result 6) has been provided to faculty for several years, and they have been encouraged to focus on employing student-centered strategies in their classes to improve student learning. These strategies have been documented in faculty annual reports (Tool 4, Result 4) and shared with the rest of the department. Also, the department faculty engaged in Physics Education Research (PER) bring interesting developments in the field to the attention of everyone. In this way, more effective strategies have gradually been adopted by most of the department, resulting in a gradual improvement in FCI gain scores to the point that most sections of the relevant courses are now attaining the department goal of 40%.

Link to 'Tech Tomorrow' Strategic Plan: General Education Curriculum
High Impact Practices
Programs, Certificates, and Training

Change Related to Program Goals 1 & 2 - Increasing Astronomy offerings

Goal/Objective/Outcome Number: Program Goals 1 & 2

Program Changes and Actions due to Results:

Our introductory Astronomy classes have been very popular for the past few years, with many students expressing a desire to take their studies in this area to a higher level. In addition, many visiting prospective students and current physics majors express an interest in astronomy. Seeing this as a potential recruiting opportunity (Program Goal 1) we have decided to expand our Astronomy offerings. To this end we have:

- Introduced a new upper-division course in Observational Astronomy (ASTR 3100) to be taught for the first time in Fall 2019.
- Had a program leading to a minor in astronomy approved by the university, also to being in Fall 2019. (This also involves a new course in Planetary Geology developed and taught by Earth Sciences.)
- Developed a program of study within our Option II program for a B.S. in Physics with an emphasis in Astronomy.

Link to Assessment:

The number of physics majors seems to be remaining relatively stable at around 30, which is significantly below the current goal of a five-year average of 50. (Program Goal 1, Result 1) While there is likely no single strategy that can increase our majors by this amount, we continue to try measures that have the potential to recruit more students. Noting the popularity of astronomy, the introduction of this course and programs is the latest of these efforts. We will monitor its effect over the coming years by using Tool 1 - Count of Physics Majors, but we will also count the number of astronomy minors awarded. Students in the Observational Astronomy course will also be expected to contribute to outreach efforts at the STEM Center (Program Goal 2).

Link to 'Tech Tomorrow' Strategic Plan: Experiential Learning
General Education Curriculum
Programs, Certificates, and Training

Change related to Learning Outcome 1 and Program Goal 3 - Adoption of LEAP Curriculum

Goal/Objective/Outcome Number: Program Goal 3 and Learning Outcome 1

Program Changes and Actions due to Results:
We would like to offer all sections of PHYS 2010 and PHYS 2020 using the integrated LEAP curriculum format. However, for now we will continue to offer one section taught in the traditional lecture+lab format.

Link to Assessment:
Students using the LEAP curriculum in the PHYS 2010 course show vastly superior performance on the Force Concept Inventory diagnostic test (Tool 6, Results 6) consistently surpassing the department goal of a gain of 40% (Learning Objective 1), whereas those in traditionally taught sections do not. However, in offering all sections in this format we found that some students could not fit the three 2-hours blocks required into their class schedules. In addition we do not yet have enough instructors who feel comfortable with the LEAP format to implement it in all sections. We continue to brainstorm how we could accommodate all students with the LEAP format, but have so far been unsuccessful. Therefore we will reluctantly continue to offer one section of both PHYS 2010 and PHYS 2020 in the traditional format.

Link to 'Tech Tomorrow' Strategic Plan: General Education Curriculum
High Impact Practices
Programs, Certificates, and Training

Change related to Learning Outcome 1 and Program Goal 3 - Development of Online Introductory Classes

Goal/Objective/Outcome Number: Program Goal 3 and Learning Outcome 1

Program Changes and Actions due to Results:
For the past several years significant numbers of TTU students have chosen to take the online TN eCampus versions of PHYS 2110 and PHYS 2120. While for some this is because of the perceived ease of these classes compared to the on-ground counterparts, for others it is because of the convenience in scheduling that such a class offers. Unfortunately these online classes do not prepare students well, particularly in the area of needed laboratory skills. The TTU physics department has therefore resolved to develop its own online versions of these courses, focusing on maintaining high quality while employing current best practices in online delivery in general and physics content in particular. The working group formed last year has developed what we deem as an acceptable format, and the first version of online PHYS 2110 will be offered in the fall of 2019.

Link to Assessment:
The department will use the established FCI diagnostic test (Tool 4, Result 4) to assess student learning in this new online course compared to current on-ground versions.

Link to 'Tech Tomorrow' Strategic Plan: General Education Curriculum
High Impact Practices
Programs, Certificates, and Training

Change related to Program Goal 3 - Video of classes

Goal/Objective/Outcome Number: Program Goal 3

Program Changes and Actions due to Results:
In the past, reviewing video of classes (Tool 5) being taught has given valuable feedback to faculty on their teaching (Program Goal 3). However, with the adoption of more student-centered strategies the focus of classroom activity has moved from the instructor to several groups of students working together in different parts of the room. This is more difficult to capture using a simple video camera. It is also extremely time consuming to review, to the extent that for the

last few years we have not recorded any video in classes that were not being studied for education research purposes associated with externally funded grants (Result 5). For these reasons we have decided to abandon the tool of video recording classes by all faculty.

Link to Assessment:
Program Goal 3 is still addressed by Tools 4, 6, & 10, and these have been the primary drivers of recent improvements in instruction reflected in Results 4 & 6. Since the videoing of classes (Tool 5) has not played a role in these improvements, and is labor intensive, its abandonment should not adversely affect the ongoing improvement.

Link to 'Tech Tomorrow' Strategic Plan: General Education Curriculum