Institutional Effectiveness
2018-2019

Program: Physics BS

College and Department: College of Arts & Science – Department of Physics

Contact: Stephen Robinson

Mission: 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:

1. a coherent program of study leading to a B.S. in Physics, and
2. 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.

Program Goals:

Program Goal 1 - The Department will recruit and retain sufficient majors for a thriving educational program.

- Increase majors at least one per year. Having sustained an average of at least 30 majors for several years, the current minimum acceptable threshold is that the average number of majors should not drop below 30.

Program Goal 2 - The Physics Department will contribute to the mission of the Millard Oakley Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM).

- The majority of faculty in the department will support the center by teaching at least one class using its facilities and/or facilitating activities in center outreach events.
- Physics students will engage in at least three center outreach activities per year.

Program Goal 3 - Ensure the use of effective and innovative pedogeological methods within the classroom.

- All faculty will report on changes/innovation in instruction in their annual reports, reflecting on their utility with regard to student learning and attitudes. Changes that result in improved student performance are expected to be adopted and will be shared with the department as a whole. As a minimum, faculty are expected to report on one such strategy per year.

Program Goal 4 - Provide opportunities for all physics majors to gain experience in authentic basic or applied research.

- All faculty engaged in research in suitable fields will seek support to engage interested physics majors in their work. Opportunities at other institutions and in other fields will also be made known to physics majors. The targeted outcome is that all physics majors will have the opportunity to engage in such opportunities as many times as they wish during their TTU career. At a minimum, any interested student should engage in at least one such opportunity.

Student Learning Outcomes:

Student Learning Outcome 1 - Students completing calculus-based and algebra-based introductory physics courses will demonstrate increased understanding of foundational basic concepts in mechanics.

- Students will achieve an average normalized gain score of at least 45% on a standard diagnostic test. For many years the targeted goal was a gain of 40%, but with recent improved performance, this year the target was raised to 45%. Currently, the minimum acceptable performance for any particular class section is a 30% gain, and any gain greater than 50% is regarded as exemplary.

Student Learning Outcome 2 - Students graduating in physics will demonstrate an understanding of the basic principles and foundations of physics.

- Graduating seniors will score, on average, at or above the 75^{th} percentile on the ETS Major Feld Test in Physics. The threshold of acceptability is to have all seniors score at or above the 50th percentile, thus maintaining a claim that TTU physics graduates are 'above average'.

Student Learning Outcome 3 - Students graduating in physics will demonstrate the skills and techniques necessary to engage in authentic experimental investigation.

- Students will demonstrate their ability to engage in experimental investigations by meeting or exceeding the minimum standards of the capstone Advanced Experimental Physics course (PHYS 4710 or PHYS 4711). The targeted outcome is that at least 75% of students should meet or exceed the minimum standards.

Student Learning Outcome 4 - Students graduating in physics will demonstrate the ability to communicate their understanding orally in a presentation format.

- Students will demonstrate their ability to effectively communicate their capstone Advanced Experimental Physics project (PHYS 4710 or PHYS 4711). The targeted outcome is that at least 75% of students should meet or exceed the minimum communication standards on the project rubric.

Student Learning Outcome 5 - Students graduating in physics will have received an introduction to a range of common technological tools appropriate to physics and related disciplines.

- All graduating physics majors and alumni report being adequately prepared to use technological tools appropriate to physics and related disciplines in their employment or graduate studies.

Student Learning Outcome 6 - The TTU physics program will give students sufficient preparation in content and skills/techniques to continue to graduate school or obtain suitable employment.

- All graduating seniors and alumni will report being well prepared to continue on to graduate school in physics (or a closely related discipline) or to enter immediate employment, whichever is relevant to their particular situation.

Student Learning Outcome 7 - Students graduating in physics will demonstrate the skills and techniques needed to engage in planning and carrying out basic or applied research.

- Students will demonstrate competency by completing a research project in PHYS 4730 (Research Planning) and PHYS 4740 (Research) courses taken as seniors. Students will meet or exceed the minimum standards of the research course (PHYS 4730 or PHYS 47140). The targeted outcome is that at least 75% of students should meet or exceed the minimum standards.

A departmentally developed curriculum map can be found in Appendix 1 that shows the connections between courses and student learning outcomes.

Assessment Methods:

PG 1: The Department will recruit and retain sufficient majors for a thriving educational program.

Department Records: 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. The department keeps 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.) 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).

PG 2: The Physics Department will contribute to the mission of the Millard Oakley Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM).

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PG 3: Ensure the use of effective and innovative pedogeological methods within the classroom.

Annual Faculty Reports: 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.

PG 4: Provide opportunities for all physics majors to gain experience in authentic basic or applied research.

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SLO 1: Students completing calculus-based and algebra-based introductory physics courses will demonstrate increased understanding of foundational basic concepts in mechanics.

Force Concept Inventory: The Force Concept Inventory is a nationally recognized diagnostic test of basic conceptual understanding and 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 normalized gain score, used to judge improvement in understanding, is a measure of the actual improvement in performance after instruction, versus the maximum possible improvement.

SLO 2: Students graduating in physics will demonstrate an understanding of the basic principles and foundations of physics.

Major Field Test: The ETS Major Field Test in Physics is a 70-item multiple-choice test that covers: Classical Mechanics and Relativity; Electromagnetism; Optics and Wave, Thermodynamics and Statistical Mechanics; Quantum Mechanics and Atomic Physics; and other Special Topics. All physics graduates will take the ETS Major Field Test in Physics during their final semester at TTU. Due to a low number of students, only two sub-scores are provided with the Exit exam results.

SLO 3: Students graduating in physics will demonstrate the skills and techniques necessary to engage in authentic experimental investigation.

PHYS 4710/4711 Capstone Course: 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.

SLO 4: Students graduating in physics will demonstrate the ability to communicate their understanding orally in a presentation format.

PHYS 4710/4711 Capstone Oral Comm.: 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.

SLO 5: Students graduating in physics will have received an introduction to a range of common technological tools appropriate to physics and related disciplines.

Exit Interviews: Exit Interview 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.

Alumni Surveys: Because of the low number of physics graduates, the alumni 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 2019 in conjunction with the department's scheduled academic audit.)

SLO 6: The TTU physics program will give students sufficient preparation in content and skills/techniques to continue to graduate school or obtain suitable employment.

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SLO 7: Students graduating in physics will demonstrate the skills and techniques needed to engage in planning and carrying out basic or applied research.

PHYS 4730 (Research Planning) and PHYS 4740 (Research) Capstone: 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 judge students' competence in planning and conducting research and communication.

Results:

Program Goal 1 - The Department will recruit and retain sufficient majors for a thriving educational program.

- *Increase majors at least one per year. Having sustained an average of at least 30 majors for several years, the current minimum acceptable threshold is that the average number of majors should not drop below 30.*

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.

Program Goal 2 - The Physics Department will contribute to the mission of the Millard Oakley Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM).

- *The majority of faculty in the department will support the center by teaching at least one class using its facilities and/or facilitating activities in center outreach events.*
- *Physics students will engage in at least three center outreach activities per year.*

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.

Program Goal 3 - Ensure the use of effective and innovative pedogeological methods within the classroom.

- *All faculty will report on changes/innovation in instruction in their annual reports, reflecting on their utility with regard to student learning and attitudes. Changes that result in improved student performance are expected to be adopted and will be shared with the department as a whole. As a minimum, faculty are expected to report on one such strategy per year.*

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.

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 3, we are considering abandoning this particular measure.

Program Goal 4 - Provide opportunities for all physics majors to gain experience in authentic basic or applied research.

- *All faculty engaged in research in suitable fields will seek support to engage interested physics majors in their work. Opportunities at other institutions and in other fields will also be made known to physics majors. The targeted outcome is that all physics majors will have the opportunity to engage in such opportunities as many times as they wish during their TTU career. At a minimum, any interested student should engage in at least one such opportunity.*

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.

Student Learning Outcome 1 - Students completing calculus-based and algebra-based introductory physics courses will demonstrate increased understanding of foundational basic concepts in mechanics.

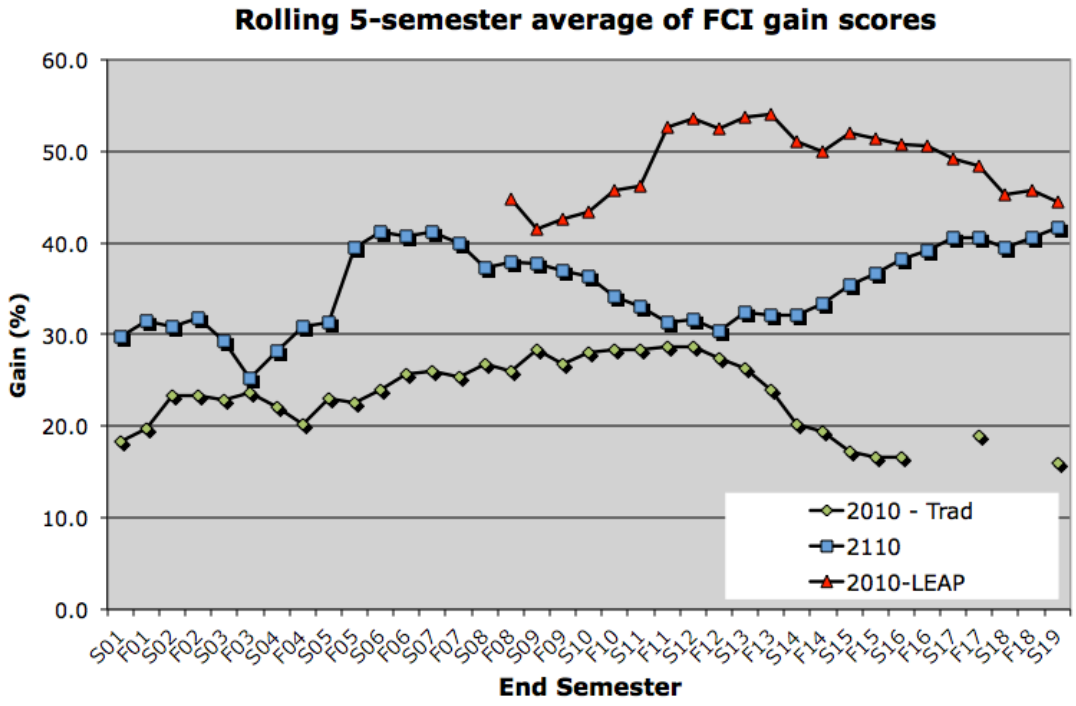
- *Students will achieve an average normalized gain score of at least 45% on a standard diagnostic test. For many years the targeted goal was a gain of 40%.* Currently, the minimum acceptable performance for any particular class section is a 30% gain, and any gain greater than 50% is regarded as exemplary.

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.

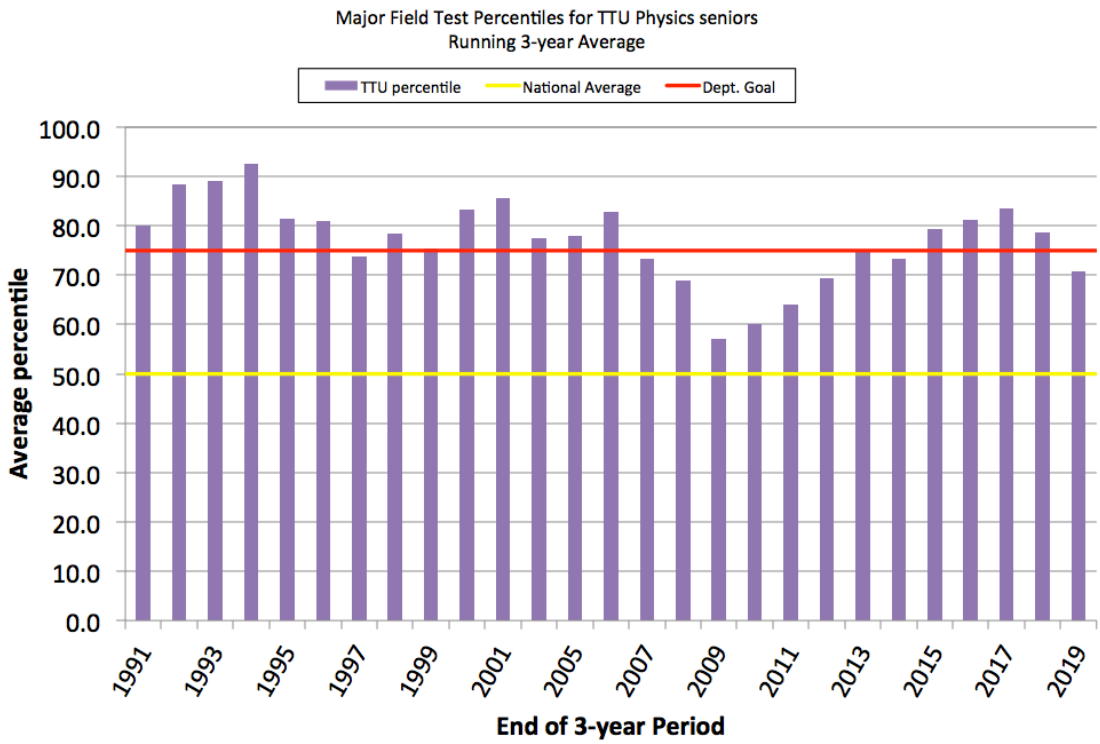
The graph below shows the rolling 5 semester average of FCI gains in relevant courses and a fuller report on a continuing longitudinal study is attached.



Student Learning Outcome 2 - Students graduating in physics will demonstrate an understanding of the basic principles and foundations of physics.

- *Graduating seniors will score, on average, at or above the 75th percentile on the ETS Major Feld Test in Physics. The threshold of acceptability is to have all seniors score at or above the 50th percentile, thus maintaining a claim that TTU physics graduates are 'above average'.*

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.

Student Learning Outcome 3 - Students graduating in physics will demonstrate the skills and techniques necessary to engage in authentic experimental investigation.

- *Students will demonstrate their ability to engage in experimental investigations by meeting or exceeding the minimum standards of the capstone Advanced Experimental Physics course (PHYS 4710 or PHYS 4711). The targeted outcome is that at least 75% of students should meet or exceed the minimum standards.*

Three physics majors took either the PHYS 4710 or 4711 course this year, only two of who met the minimal expectations.

Student Learning Outcome 4 - Students graduating in physics will demonstrate the ability to communicate their understanding orally in a presentation format.

- *Students will demonstrate their ability to effectively communicate their capstone Advanced Experimental Physics project (PHYS 4710 or PHYS 4711). The targeted outcome is that at least 75% of students should meet or exceed the minimum communication standards on the project rubric.*

Three physics majors took either the PHYS 4710 or 4711 course this year, all three were judged by the faculty to have made acceptable oral presentations.

Student Learning Outcome 5 - Students graduating in physics will have received an introduction to a range of common technological tools appropriate to physics and related disciplines.

- *All graduating physics majors and alumni report being adequately prepared to use technological tools appropriate to physics and related disciplines in their employment or graduate studies.*

Exit Interviews: In exit 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.

Alumni Survey: 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. TTU physics students continue to be highly satisfied with the program and the level of preparation they receive for their future careers.

Student Learning Outcome 6 - The TTU physics program will give students sufficient preparation in content and skills/techniques to continue to graduate school or obtain suitable employment.

- *All graduating seniors and alumni will report being well prepared to continue on to graduate school in physics (or a closely related discipline) or to enter immediate employment, whichever is relevant to their particular situation.*

Exit Interviews: In exit 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.

Alumni Surveys: 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. TTU physics students continue to be highly satisfied with the program and the level of preparation they receive for their future careers.

Student Learning Outcome 7 - Students graduating in physics will demonstrate the skills and techniques needed to engage in planning and carrying out basic or applied research.

- *Students will demonstrate competency by completing a research project in PHYS 4730 (Research Planning) and PHYS 4740 (Research) courses taken as seniors. Students will meet or exceed the minimum standards of the research course (PHYS 4730 or PHYS 47140). The targeted outcome is that at least 75% of students should meet or exceed the minimum standards.*

PHYS 4730 (Research Planning) and PHYS 4740 (Research) Capstone: In their second implementation, three students completed these courses. All met the minimal standards for success thus demonstrating their attainment of the required skills and in planning and carrying out research.

Student Research Involvement: 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.

Exit Interviews: In interviews conducted just before graduation four seniors expressed general satisfaction with their preparation at TTU. 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.

Modifications for Improvement:

Student Learning Outcome 1 and Program Goal 3

For many years the department goal for the Force Concept Inventory administered as a pre-/post-test in PHYS 2010 and PHYS 2110 has seen 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. Therefore, for the coming year we will raise this goal to a gain of 45%.

Detailed feedback on FCI results 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 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%.

Student Learning Outcome 1 and Program Goal 3

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.

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.

Student Learning Outcome 1 and Program Goal 3

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.

The department will use the established FCI diagnostic test to assess student learning in this new online course compared to current on-ground versions.

Program Goal 3

In the past, reviewing video of classes 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. For these reasons we have decided to abandon the tool of video recording classes by all faculty.

Program Goal 3 is still addressed by multiple measures and these have been the primary drivers of recent improvements in instruction. Since the videoing of classes has not played a role in these improvements, and is labor intensive, its abandonment should not adversely affect the ongoing improvement.

Appendices

1. Physics BS Curriculum Map
2. Alumni Survey Report

Appendix 1: Physics BS Curriculum Map

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

Appendix 2: Alumni Survey Report

Report on Physics Department Alumni Survey - 2018

Introduction

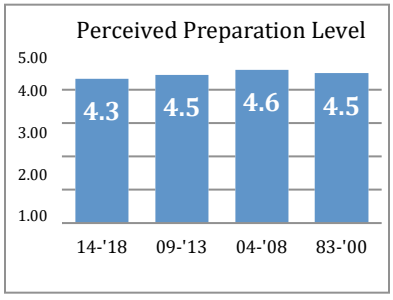
During the fall of 2018, TTU physics alumni were contacted and asked to complete the same online survey we have used in the past (hosted by Qualtrics). From this, and previous requests, we now have responses from sixty-eight alumni, with graduation years from 1947 to 2017. In order to extract feedback relevant to the current program we limited analysis to respondents who have graduated since 1983, when the program was significantly revised. Of those forty-four respondents, forty continued on to graduate school, in either physics (23) or some other field (17), while four immediately entered employment after graduating. In order to determine any recent trends, this group was subdivided into four cohorts: 2014-2018 (N = 3), 2009-2013 (N = 11), 2004-2008 (N = 10) and 1983-2000 (N = 20) graduates. Unfortunately, with only three responses from our most recent cohort, results for this group cannot be considered to be particularly reliable.

Overall Preparation

The first three questions on the survey gathered demographic information. The following questions asked alumni to rate their overall level of preparation, both absolutely and relative to their peers.

How would you rate the overall level of preparation that the TTU physics program provided you toward your next career step?

(1 = Very poor, 2 = Poor, 3 = Adequate, 4 = Good, 5 = Excellent)



The average rating given by all cohorts was between 4.3 and 4.6, indicating that on average our alumni continue to think our program did an excellent job preparing them for their next career step.

(Note: All comments provided here come from the most recent survey responses.)

Comments:

I cannot recall an instance in a graduate course where I had not seen the material or a popular problem before, plus the problem solving skills I gained from TTU helped me excel in my course work and research.

The presentation of course material in classical, thermal, quantum, and E&M are much more abstract at the graduate level, which was difficult for me to adjust to. That said, I don't think as an undergrad I would have comprehended a more advanced presentation of these materials. I was encouraged to seek external summer research opportunities, which were invaluable to me.

In general the Tech physics program prepared me very well for graduate level physics. This was in large part due to the efforts made to offer additional classes at a high level, including nuclear physics, computational physics, and particle physics which were all very valuable for me, as they allowed me to be on equal footing with peers from much larger universities. From a research perspective, I wasn't on the level of some peers who had worked for several years on projects based at their undergraduate institute,

but the opportunity to participate in summer projects was essential to my acceptance and success in graduate school.

Excellent level of preparation. Numerical methods CSC course, research experience, advance physics lab, and knowledge of LaTeX stand out as skills (or courses that provided skills) that have persisted as useful throughout my educational and professional development.

Prepared well for grad school but not so much for trying to find a job.

Decent for the graduate coursework, but I succinctly remember not being prepared adequately for the Physics Subject GRE.

I wouldn't expect my physics degree to prepare my for graduate school in abstract math

Not the most applicable for first job after school, but extremely helpful for second job

Switching fields made it more difficult not the performance of the TTU Physics Dept

The greatest thing about my education in physics at TTU was that I graduated with a firm grasp of physics and mathematics and how to think rationally about problem solving as opposed to rote memorization. This was an excellent preparation for subsequent career where I have worked in a variety of areas involving engineering and applied science.

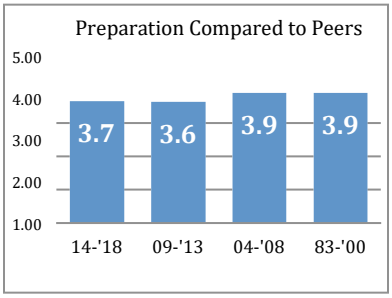
Much better than too many

Compared to my peers, my undergraduate curriculum was mostly good, particularly classical mechanics and electromagnetism, but could have used more statistics and thermodynamics.

When comparing yourself to others following a similar career path, but having graduated from other programs, how would you rate your level of preparation?

(1 = Much Worse, 2 = Worse, 3 = About the same, 4 = Slightly Better, 5 = Much Better)

The average rating given by the earlier cohorts (1983 – 2008) were both 3.9 while the most recent cohorts (since 2009) have dropped slightly. These results still indicate that TTU physics graduates continue to feel that their preparation compares favorably to that of their peers.



Comments:

I don't have a large sampling size

Everyone I've talked to has a different skill set. I think the most valuable skill early in grad school is an ability to converse with fellow students. I always tried to do everything myself, and I didn't realize how much I was losing by not having conversations. That said, I have computational skills that my cohorts envy. Also, I think the advanced lab courses I took at TTU were more helpful than some of my graduate cohorts reported.

Compared to universities of a similar size Tech gave me excellent preparation, and I passed my qualifying exam on the first attempt. Compared to major research universities, I was a bit behind on the fundamentals of introductory physics, especially optics and circuits. This is somewhat unavoidable, as the largest physics programs in the US are able to offer a track tailored for physics majors right from the start.

The other people who followed a similar path as me came from strong Physics programs as well. It is a testament to TTU's Physics program that I felt that I was on the same level as the other people I knew who followed a similar path as me.

Compared to other students, I felt that I was better prepared for research activities like programming due to summer undergrad research, but was probably just a bit behind the curve for things like grad-level homework in core classes.

I don't really know many people in my situation...

Compared to much larger schools, I had fewer options for extra classes. Compared to similarly-sized or smaller schools, I had a much stronger background in the core classes.

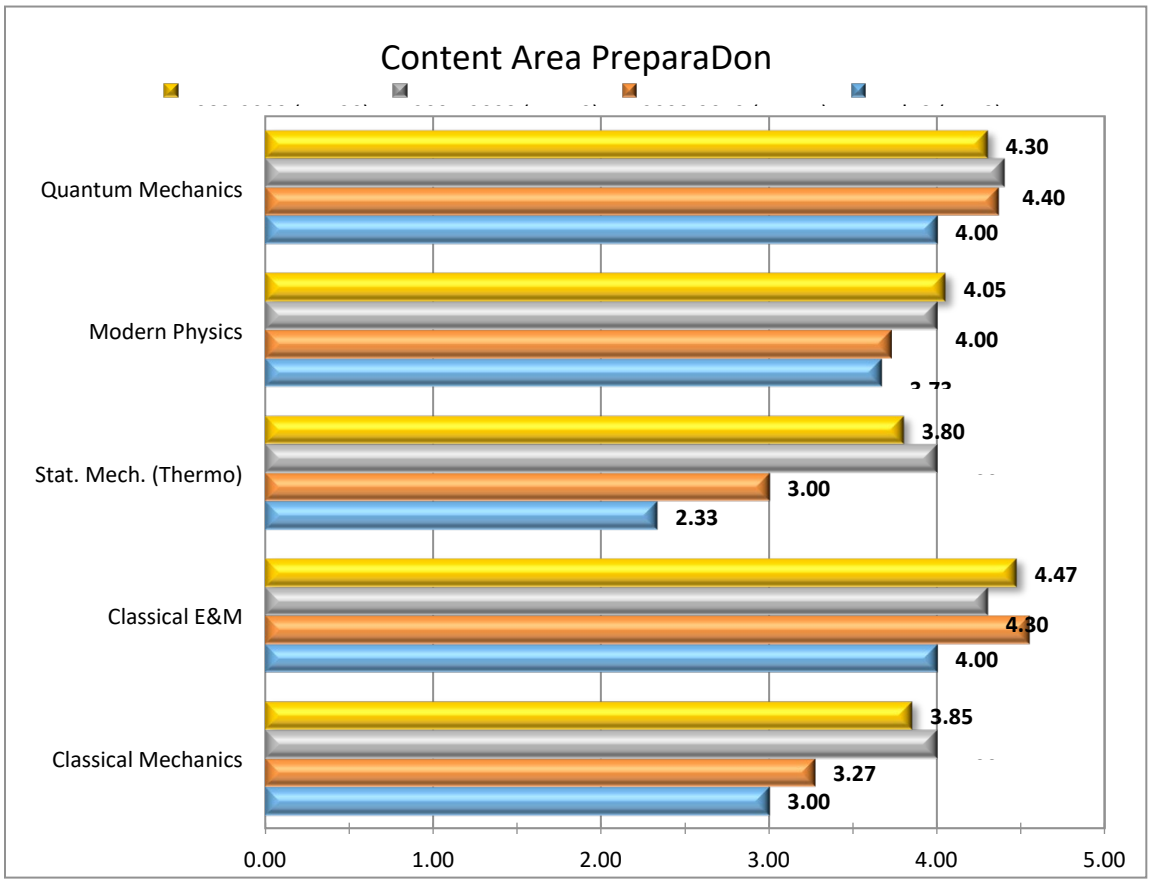
The following is from one individual:

> *Comparitive weak subjects: During my brief time in grad school, I noticed many people had an advantage on me in classical mechanics. While it personally wasn't my best subject, it seems many people had a semester more than we did of this topic.*
>
> *Not so much in school, but in the workplace, I have had to do a lot of catching up on programming.*
>
> *Strong subjects: I felt well prepared in quantum mechanics and E&M compared to others. Especially for quantum, I felt way ahead with what we covered when speaking to others in school.*
>
> *I would also say the advanced senior lab was a good experience that many others seemingly did not have. I think it got me into good habits and skills I use at my current job.*

Specific Topics

The next question asked for feedback on the level of preparation in specific content areas. The average rating for each cohort is shown below.

(1 = Very poor, 2 = Poor, 3 = Adequate, 4 = Good, 5 = Excellent)



Again, this shows that alumni continue to rate their preparation in Electricity and Magnetism and Quantum Mechanics as good to excellent. Statistical and Classical Mechanics have consistently had the lowest perceived levels of preparation with Classical Mechanics dropping to 'Adequate' and Statistical Mechanics dropping below 'Adequate' and approaching 'Poor'. However, these indications should be tempered by the low number of responses from the most recent cohort.

Comments:

We have no relativity course, modern physics needed a rehaul when I was there

I landed in computational biophysics research, which is heavy in statistical mechanics; while I had a good understanding of basic terms when I started, I felt a little underprepared in terms of intuition.

Preparation in the fundaments of introductory physics, including optics and modern physics, are essential to performing well on the physics GRE. I felt my relative preparation in advanced physics was superior, which impacted my performance. A two course modern physics track could be beneficial for this, though would be challenging to fit into the program.

My preparedness in these classes were a function of who taught them, not the program overall

As I mentioned earlier, I would give advanced lab an excellent rating.

I felt well prepared for grad school in physics, but I wasn't particularly interested in continuing in that direction

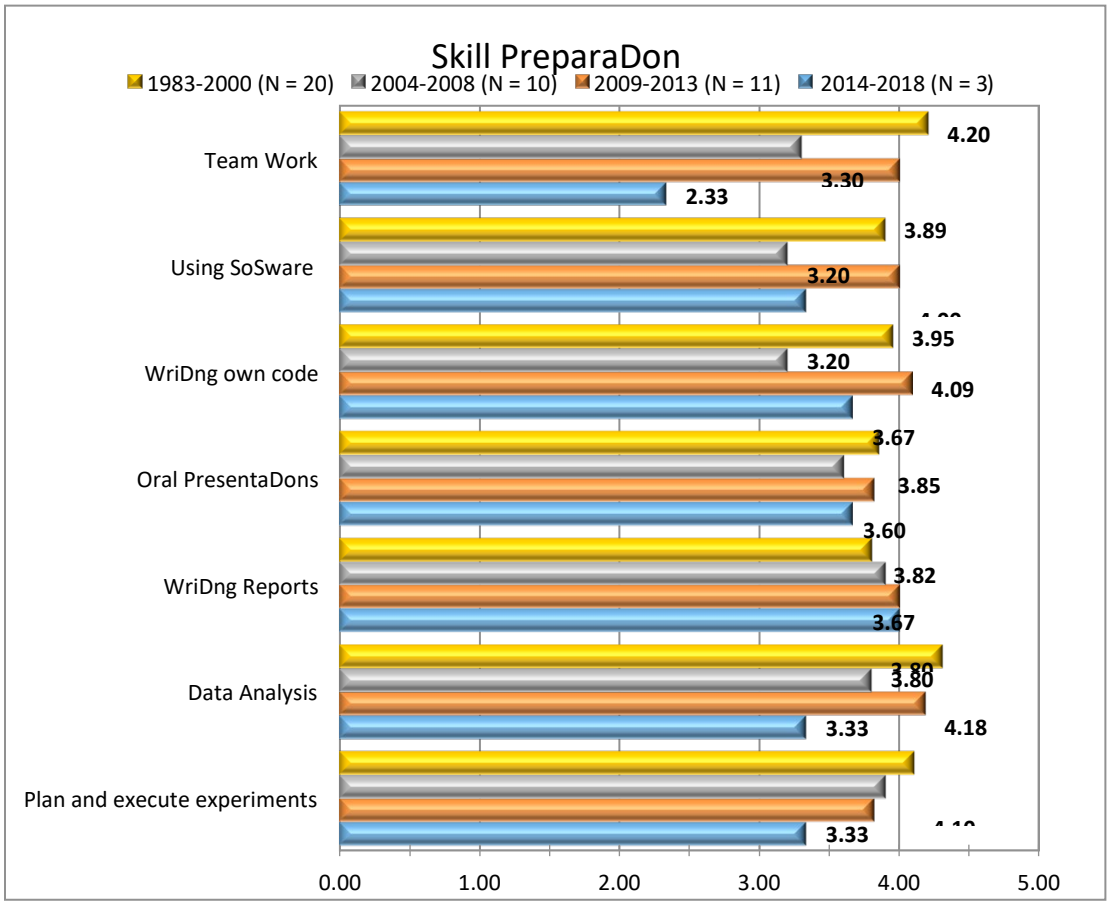
Linear algebra should have been a required course. Summer internships were THE BEST

I had no formal training in statistics, which I though would have been helpful. I wished I had extra astronomy/astrophysics options besides the Astronomy 1 and 2 classes.

Specific Skills

Question 7 asked for feedback on the level of preparation in specific skills that we would like our students to acquire. (Working as a member of a team; Using commercial software packages; Writing their own computer code; Making oral presentations; Writing reports; Analyzing experimental data; Planning and executing experiments.) Again, the average rating for each cohort is shown below.

(1 = Very poor, 2 = Poor, 3 = Adequate, 4 = Good, 5 = Excellent)



Comments:

Most of answers of poor listed above are from my own experience and lack of taking advantage of what the program offered

Most of the skills listed above there were both opportunities and encouragement to develop. There were many discussions, for instance, of opportunities to develop computer skills or oral presentations skills, and discussions of how ubiquitous these activities are. There were ample opportunities for students to work together on coursework, but I missed the memo in undergrad that the ability to discuss problems and speak about physics concepts conversationally were important.

If possible, more opportunities for research concurrent with the semester would be beneficial for undergraduates. Balancing research responsibilities with other obligations is one of the major challenges of graduate school which is unique from my undergraduate experience.

Although I felt somewhat equivalent to contemporaries in didactic training, I felt I was in an overall stronger position with regard to the above skills.

It would have been nice to have more exposure to handling data on (remote) Linux/Unix environments instead of Windows. I had personal interest so had dabbled in it in my spare time, but I saw a good majority of incoming students that would have really benefited from learning how to use the command line earlier than grad school.

Coding is so important. When I was working for the army i needed a lot of coding knowledge, but only a little bit of dynamics or e&m. I think we could have used more coding exercises in the upper level classes

I think labs and internships are the best means of preparation for a job. Exposure to wide range of theoretical and applied concepts is important also. My dual degrees in physics and mechanical engineering have been immeasurably beneficial in my current position.

Commercial software was in it's infancy when I graduated in 1986.

For people like me who graduated so long ago, there were no commercial computer software packages, so there should be an N/A category. I gained terrific experience in analyzing/writing code during my summer research with Dr. Mateja, rather than in a class. That experience also helped prepare me for working as part of a team.

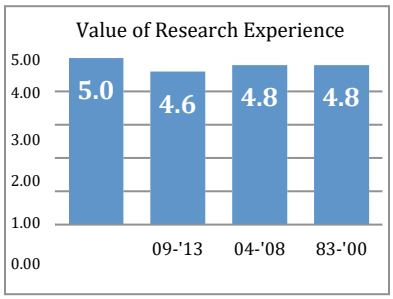
These results indicate that alumni continue to consider the overall level of preparation they received in particular skills to be good. However, the recent low rating for developing skills working as a team is of some concern. We feel that the increased emphasis on undergraduate research particularly addresses this skill, but there has not yet been time to see the results of this.

Research Experience

The department has been nationally recognized for its long-standing efforts to involve undergraduates in research. This has been done either by faculty employing students as summer research assistants, or by encouraging them to apply for summer REU programs elsewhere. The value of this effort is evident in the responses to the question:

Please rate how valuable you feel your research experience was in your career preparation.

(1 = Worthless, 3 = Somewhat valuable, 5 = Extremely valuable)



A significant majority of respondents gave their research the highest possible rating giving an overall average of 4.8 out of 5 across all respondents.

Comments accompanying these ratings were all positive.

Comments:

A variety of experiences was invaluable. In my case, it largely confirmed the expectations that I had, but I still developed a clearer vision of my career goals because of them.

Without this experience, I would never have been considered for major graduate programs. It also allowed me to evaluate whether or not I was interested in continuing in academics.

My research experience with Dr. Kozub was the single most important aspect of my training at TTU. My PhD advisor would not have taken me as a graduate student if not for this opportunity and training, and I was not admitted to any other PhD programs in Medical Physics.

Dr. Kozub had me take a position at Oak Ridge the summer after I graduated. It was very useful, and some of what I learned there has helped me in my current position. It was also extremely important just to have some relevant work experience when applying to jobs.

It was programming visualizations of fluid vectors. Knowing some programming aided in my career preparation.

Probably the most valuable data analysis education I got

Please invite, pressure, and cajole students into doing this. I didnt know about the potential for these opportunities at first, didn't appreciate it initially, but quickly came to realize its value.

I participated in both an on-campus research experience with a faculty member, and then two external experiences - REU at Notre Dame, and SULI at Brookhaven National Lab. I found all three experiences valuable in their own ways - I learned how to work on my own, write analysis code, interpret older analysis code, experience other university campuses, make broad contacts within the community, experience a national lab setting and see what large collaborations did, experience a physics press release at BNL and meet a Nobel laureate.

Worked with Munther Hindi and Steve Robinson. Travelling 3 summers for a great experience.

As noted in the previous comment box, I consider my summer research experience with Dr. Mateja to have been extremely valuable. We went to Florida State for the summer to analyze data from its linear accelerator. Even though I didn't have any particular interest in nuclear physics that was a great experience.

At the time, the ability to work on research with faculty as an undergraduate was most unusual. It was the best part of the undergraduate experience. (Thank you, Ray Kozub.)

Final Comments

Respondents were asked for any final comments about the degree program in general.

My current position will be changing soon - In July, 2019 I will be starting as an Assistant Professor at the University of Iowa.

Something I didn't see mentioned here was the ability to TA. I think that was a valuable experience.

The great irony of my career is that the difficulty of the E&M classes are partly what deterred me from graduate studies in physics, and yet my current job at Boeing (of 8+years) is in the Electromagnetic Effects group. Encourage students to persevere, take all the opportunities available, and see what happens.

My Physics degree from Tech has been a great benefit to me while working in a non-traditional post B.S. career path. If I could ever give any advice or guidance to current majors considering such a journey I'd be happy to speak with them.

Overall, I appreciate my time at Tech and the education I received.