Institutional Effectiveness
2022-2023

Program: Physics BS
College and Department: College of Arts & Sciences
Contact: Stephen Robinson
Mission:

The TTU Department of Physics will promote the learning of physics and astronomy 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 various programs:

- a major program of study, with two options, leading to a B.S. in Physics
- programs of study leading to minors in Physics and Astronomy
- 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.

Attach Curriculum Map (Educational Programs Only):

		Goals/Learning Outcomes					
Course	Title	Physics knowledge	Analytical skills	Laboratory skills	Communication skills	Computational skills	Research experience
PHYS 1137	Frontiers of Physics	X			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	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	X	
PHYS 4130	Research Planning	X	X	X	X	X	X
PHYS 4140	Research	X	X	X	X	X	X

LEARNING OUTCOME 1 - STUDENT LEARNING IN INTRODUCTORY COURSES

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

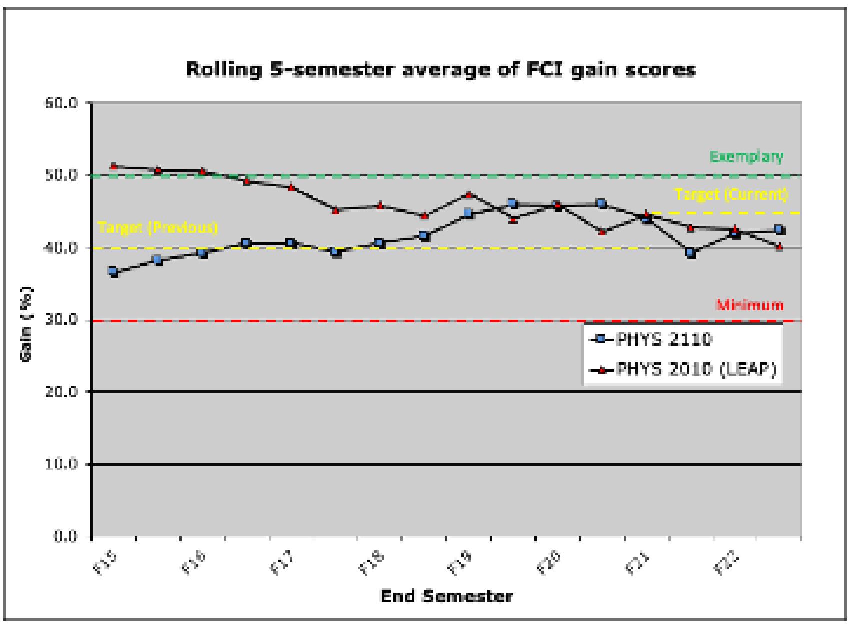
Assessment Methods:
Understanding of basic mechanics concepts will be measured using the nationally recognized Force Concept Inventory, a standard diagnostic test used at many institutions nationwide. It will be administered to all students at the beginning of both PHYS 2010 and PHYS 2110 courses, and then again after the relevant material has been covered. The normalized gain score will be used to judge improvement in understanding, and is a measure of the actual improvement in performance after instruction versus the maximum possible improvement.

Criteria for Success (Thresholds for Assessment Methods):
For many years the targeted goal was a gain of 40%, but with recent improved performance, the target has now been 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.

Results and Analysis:
The table below shows how sections of the targeted courses performed this year, in terms of the thresholds defined for this outcome.

Course	Total sections	Below minimum (<30%)	Acceptable (30% - 44%)	Attained target (45% - 50%)	Exemplary (>50%)
PHYS 2010	7	2	5	0	0
PHYS 2110	8	1	3	1	3

This graph shows a rolling 5-semester average for the performance of the two courses since 2015.



The historical trend in PHYS 2110 showed a gradual improvement, which prompted the raising of the target for this outcome to a 45% gain last year. This year's results for PHYS 2110 continue to be encouraging, with half the sections surpassing the target of a 45% gain, and only one falling below the minimum. We ascribe this mainly to improvements in instruction (see Program Goal #2) with instructors focusing more on strategies to engage students in their classes.

Unfortunately, the performance in the PHYS 2010 class was not satisfactory, with no sections attaining the target gain, and two being below minimum. This is disappointing as this course as historically performed well in regard to this outcome. We do note that the recent change in class schedules has (because of the way this course is structured) effectively reduced the amount of useful class time available. This, in turn, has meant that for the fast four semesters, some topics that are addressed by this diagnostic test were given less time (or not covered at all).

Use of Results to Improve Outcomes:
With the encouraging performance in PHYS 2110 we will continue to promote the use of student-centered instructional strategies in this course. It will be interesting to see if further improvements result,

The situation in PHYS 2010 is more complicated. We must first consider whether simply making changes in emphasis/ordering will allow us to again cover all the topics addressed by the diagnostic test. Beyond this, it is possible that the apparent gradual decline in gains in conceptual understanding is offset by improvements in other areas of the course not addressed by this diagnostic test, such as quantitative problem solving. If this is so, we must then consider if this trade-off is acceptable and, if so, whether we want to adjust the target for this outcome.

LEARNING OUTCOME 2 - LEARNING OF PHYSICS MAJORS

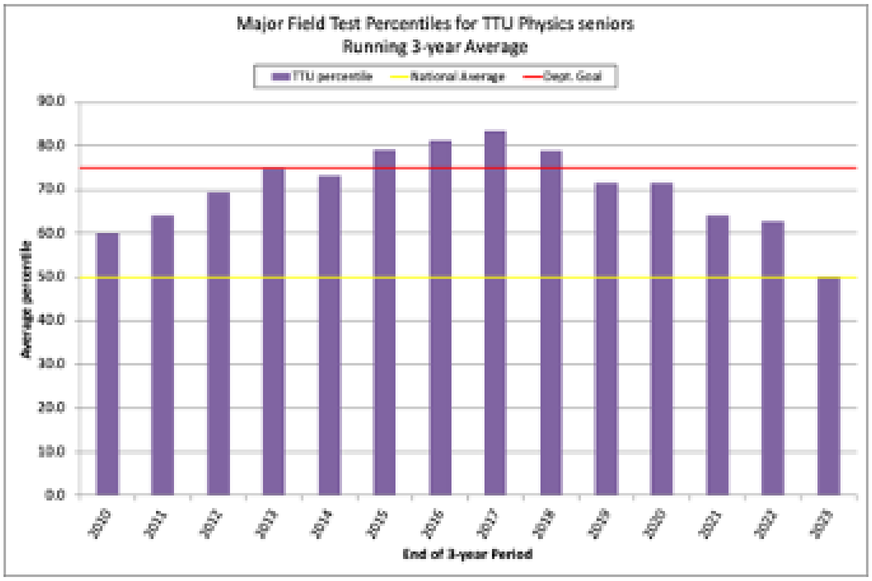
Define Outcome:
Students graduating in physics will demonstrate an understanding of the basic principles and foundations of physics.

Assessment Methods:
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.

Criteria for Success (Thresholds for Assessment Methods):
The aspirational target is that graduating seniors will score, on average, at or above the 75th percentile on the ETS Major Feld Test in Physics, both on their overall score, and also on the two reported sub-scores. The threshold of acceptability is to have an average at or above the 50th percentile, thus maintaining a claim that TTU physics graduates are 'above average'.

Results and Analysis:
The five physics majors who took the Major Field Test this year scored, on average, at the 45th percentile, with only one surpassing the 75th percentile target. Because of low numbers, it is difficult to base decisions on a single year’s scores. Therefore, we use a rolling three-year weighted average to examine trends. Even, so, this brings the three-year average down to only

very slightly above the 50th percentile, the lowest it has been since the 2008/2009 academic year, as shown on the graph. Clearly, the last few years have shown a concerning trend that the reported sub-scores can reveal more about.



The table below shows the three-year averages of sub-scores on the two portions of the Major Field Test (Introductory and Advanced Physics) reported on a scale of 20-100, with the national average being approximately 50. The goal of an average at or above the 75th percentile corresponds to a sub-score of approximately 62 in each portion.

Year	Students tested	Sub-scores[2]	
		Introductory Physics	Advanced Physics
2010/11	3	57	61
2011/12	1	59	61
2012/13	5	58	68
2013/14	3	58	69
2014/15	3	61	70
2015/16	2	64	70
2016/17	3	65	69
2017/18	1	61	68
2018/19	5	59	63
2019/20	Due to Covid-19 pandemic, graduating seniors did not take test		
2020/21	2	55	60
2021/22	3	52	61
2022/23	5	44	56

These sub-scores reveal a somewhat surprising pattern, in that our majors consistently perform more poorly on introductory topics than they do on advanced topics. This suggests that we should focus our efforts on improving this outcome to address student learning of introductory topics.

Use of Results to Improve Outcomes:
In discussing these results, the faculty have considered the possible causes of the recent concerning decline, some of which may be related to our efforts to address other outcomes. First, it is thought that our increased efforts to give undergraduates genuine research experience (Program Goal 1) may be persuading some less motivated students to remain in physics, when they might otherwise have left the major. Second, it may be that some of the strategies employed in our calculus-based introductory classes (Program Goal 2, Learning Outcome 1), that mainly cater for non-physics majors, may be less suited for the few physics majors who must also take those classes.

The faculty feel that taking additional measures to help physics majors better learn introductory topics is to be much preferred to dissuading them from remaining in the major. These additional measures will include:

- Deliberate cohort building among physics majors to encourage collaborative learning.
- Explicit encouragement of mentoring of freshmen by upperclassmen.
- Closer tracking of physics majors in their introductory physics classes, to quickly identify when additional help is needed.
- Increasing the frequency of recitation/help/review sessions, which targeted physics majors will be encouraged to attend.

LEARNING OUTCOME 3 - PHYSICS SKILLS

Define Outcome:
Outcome: Students graduating in physics will demonstrate a range of competencies necessary to pursue a physics-related career. In particular, they will demonstrate the skills and techniques needed to:

- engage in authentic experimental investigation.
- communicate their work in a written format.
- communicate their work in an oral presentation format.
- use appropriate technological tools.
- engage in planning and carrying out basic or applied research.

Assessment Methods:
During their senior year, all physics majors take the following capstone set of courses:

- Advanced Experimental Physics (either PHYS 4710 (4 cr) or PHYS 4711 (2 cr))
- Computational Physics (PHYS 4130)
- Research Planning (PHYS 4730) and Research (PHYS 4740)

To be successful in this set of courses, students must apply and synthesize all of the skills addressed by this outcome, thus providing the opportunity to assess their degree of competency. In some cases, assessments of these skills may also be carried out in extracurricular contexts, such as summer research internships, student seminars, and conference presentations. The matrix below summarizes which skills may be assessed in which courses/context.

	Senior Level Courses			Extracurricular (if applicable)	
Skill	PHYS 4710/4711	PHYS 4130	PHYS 4730/4740	Research Experience	Seminar/ Conference
Experimental Investigation	X		X	X	
Written Communication	X	X	X	X	
Oral Presentation	X	X	X	X	X
Technological Tools	X	X	X	X	
Basic/Applied Research			X	X	

Each of these sets of skills will be assessed using agreed upon rubrics that are currently under development and pilot testing. Depending on the context, these rubrics will be used by course instructors, research supervisors, and other faculty.

Criteria for Success (Thresholds for Assessment Methods):
Once pilot testing of the various rubrics is complete, criteria for success will be set by the whole department. It is the intention that criteria will be set both for each set of skills separately, and for the ensemble as a whole.

Results and Analysis:
Examining such a large ensemble of skills is a new venture for the department and the development of tools to do so is taking longer than anticipated. Nevertheless, this year, subgroups of faculty developed draft learning outcomes for each set of skills. These were based on a combination of instructor experience, examination of outcomes adopted by other physics programs, and recommendations made by professional societies. These draft outcomes are given in the attached documents. While these reflect each subgroups' expectations for student learning, due simply to time constraints we have yet to agree on them as a department. Unfortunately, we did not have time to develop the rubrics by which we will quantitatively assess student mastery of these outcomes.

Nevertheless, instructors in the PHYS 4710 and PHYS 4730/4740 courses reported that the students in those classes did demonstrate a high degree of mastery of the draft outcomes in 'Experimental Investigation' and 'Written Communication'. In addition, the department faculty who attended students' end-of-course presentations, reported good performance in 'Oral Presentation'.

Use of Results to Improve Outcomes:
The next step in developing these assessments is for the department faculty to finalize the sets of outcomes, agree on rubrics for each, and pilot them during the coming year.

LEARNING OUTCOME 4 - CAREER PREPARATION

Define Outcome:
Graduates of the TTU physics program will agree that the program gave them a well-rounded, scientifically and technologically grounded preparation, with strong analytical skills, such that they were well prepared for their next career step.

Assessment Methods:

1. **Exit Interviews**: While students who are getting ready to graduate from the program 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. In their exit interviews, students will be explicitly asked about how well prepared each student feels for their next career step, both overall and in terms of individual elements.
2. **Alumni Surveys**: Because of the low number of physics graduates, surveys are administered to department alumni on an approximate 5-year cycle. Among the questions asked are how effectively graduates felt the TTU physics program prepared them for their chosen career path.

Criteria for Success (Thresholds for Assessment Methods):
All graduating seniors and alumni will agree that the program prepared them well 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.

Results and Analysis:

- **Exit Interview:** Exit Interviews were conducted with four graduating seniors this year. All were intending to go to graduate school in physics, or a closely related discipline. All deemed their preparation for graduate school to be good.
- **Alumni Survey:** A full report of our most recent survey in Fall 2019 is attached, but relevant to this SLO, alumni continue to report being highly satisfied with the program and the overall level of preparation they receive for their future careers.

With these results it seems this learning objective continues to be met.

Use of Results to Improve Outcomes:
No action is deemed necessary at this time. It is anticipated that a new alumni survey will be conducted during the coming year and a re-evaluation of this outcome will be conducted when results are known.

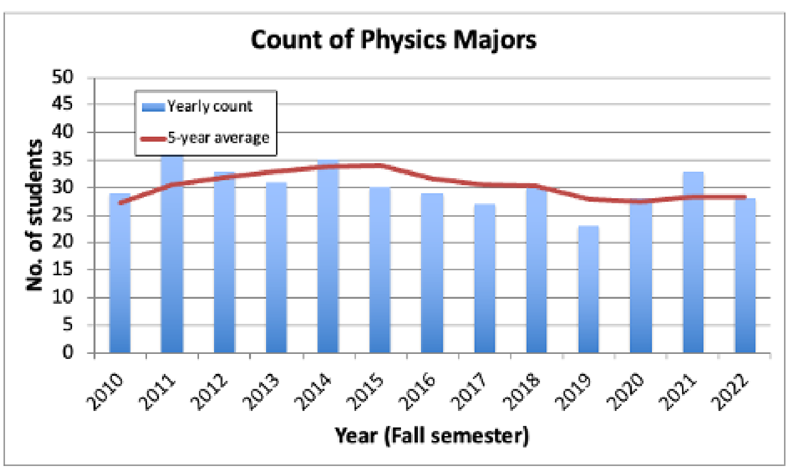
PROGRAM GOAL 1 - NUMBER OF PHYSICS MAJORS

Define Outcome:
The Department will recruit and retain sufficient majors for a thriving educational program.

Assessment Methods:
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 chair maintains a spreadsheet that tracks these numbers.

Criteria for Success (Thresholds for Assessment Methods):
The current target is that this average will increase by 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.

Results and Analysis:
At the start of this year the number of students declaring a physics major was 28, raising the 5-year average slightly to 28.4., which is still slightly below the minimum threshold of 30. In fact, despite small year-to-year fluctuations, the average continues to stay very close to this threshold.



Use of Results to Improve Outcomes:
Despite our increased efforts to raise our profile during university-wide recruitment efforts, the 5-year average still hovers around the minimum threshold. We have therefore decided that, in addition, more targeted recruitment efforts are needed. In the coming year we will begin a program in which department faculty (accompanied by current students if possible) offer to visit science classes in area high schools to make presentations about current ‘hot topics’ in physics, research currently being conducted in the department, and possible career options. To this end we will work with a retired alumnus who has volunteered to act as a liaison between the department and area schools.

PROGRAM GOAL 2 - IMPROVING INSTRUCTION

Define Outcome:
Ensure the use of effective and innovative pedagogical methods within the classroom.

Assessment Methods:
In their annual effort reports, all faculty will be expected to report on changes/innovation in instruction, reflecting on their utility with regard to student learning and attitudes. Changes that result in improved student performance will be shared with the department as a whole.

Criteria for Success (Thresholds for Assessment Methods):
As a minimum, every faculty member is expected to report on at least one such strategy per year, together with an assessment of its effectiveness.

Results and Analysis:
Every faculty member reported trying at least one strategy that falls outside the normal ‘lecture’ mode. However, in some cases, there was little or no discussion of effectiveness. Also, although outside the normal ‘lecture mode’, some reports simply replicated those from previous years. Because of this, the goal is deemed only partially met. Some strategies that were reported in a meaningful way will be shared with the department during a faculty meeting before the start of the Fall 2023 semester.

Use of Results to Improve Outcomes:
To further encourage faculty members to try different approaches, it will be emphasized in the fall faculty meeting that this element of annual reports should not rely on strategies implemented in previous years, but on genuine innovations made for the coming year. It will also be emphasized that they must include some assessment or measurement that addresses their effectiveness in terms of student attitudes or learning.

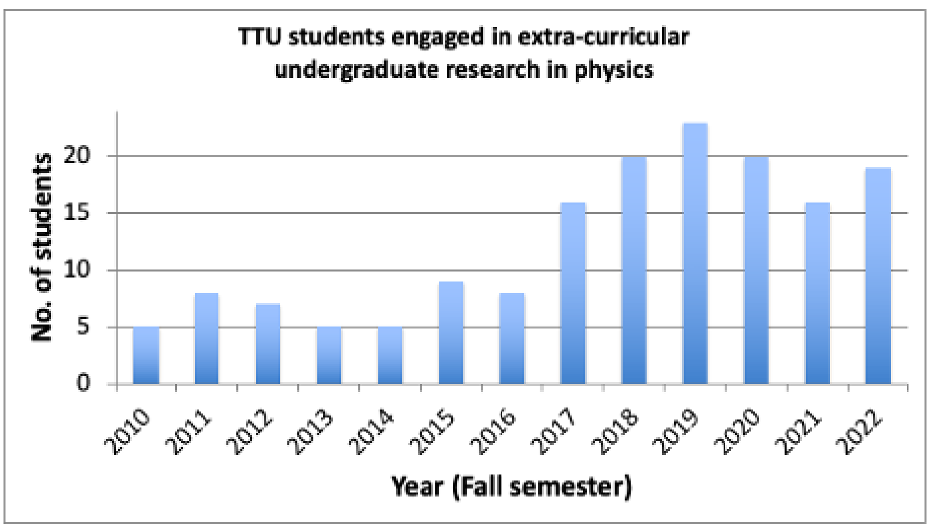
PROGRAM GOAL 3 - UNDERGRADUATE RESEARCH EXPERIENCE

Define Outcome:
All physics majors will have the opportunity to gain experience in basic or applied research.

Assessment Methods:
The department chair will keep a record of student participation in the research of department faculty members and in specialized programs for undergraduates at other institutions (e.g. REUs and SULIs). (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.)

Criteria for Success (Thresholds for Assessment Methods):
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.

Results and Analysis:
During this year a total of nineteen individual undergraduate students participated in research activities of various types with department faculty members. This continues the high level of involvement of the past several years, which is built on the deliberate recruitment of faculty members who are committed to such undergraduate engagement. Of note is the continued expansion of the areas of involvement to both astronomy and education related projects. All physics majors who desired such an experience were accommodated, thus achieving the target for this goal.



Use of Results to Improve Outcomes:
With this goal currently being achieved, we will maintain our current strategies of broadly publicizing research opportunities and requiring a commitment to undergraduate research in future tenure-track faculty searches.

Summative Evaluation:
Specific areas of concern this year are:

- Recruitment of sufficient numbers of physics majors to maintain a thriving program. As well as continuing current efforts, this will be further addressed by starting a program in which faculty and current students will visit area high schools, to try to 'enthuse' them about physics in general, and inform them about our program.
- Declining overall Major Field Test scores for Physics majors, and the lower performance on in the Introductory Physics sub-score. This will be addressed by offering physics majors more individual support from both faculty and their peers.

Assessment Plan Changes:
We will continue the development of learning objectives and rubrics to be used in assessing Learning Outcome 3, which addresses the skills and techniques we want our physics majors to acquire through their courses, and other experiences within the department.

List of Appendices:
Appendix 1: Written Communication Outcomes (draft)
Appendix 2: Computational Skills Outcomes (draft)
Appendix 3: Research Skills Outcomes (draft)
Appendix 4: Oral Communication Outcomes (draft)
Appendix 5: Experimental Investigation Outcomes (draft)
Appendix 6: Alumni Survey Report 2018

Appendix 1: Written Communication Outcomes (draft)

<u>Written Communication – Draft Student Learning Outcomes</u>

1. Students will be able to construct a written report of an investigation that adheres to the usual scientific format. It should contain the following elements:
    a. A title that is descriptive of the investigation.
    b. An abstract that summarizes the investigation and its results and conclusions in only a few sentences.
    c. An introductory section that clearly states the claim that was investigated, gives a rationale, and reviews prior work.
    d. A procedure section that describes the equipment and materials used, and clearly and concisely describes the experimental methods used.
    e. A results section that includes data tables and graphs constructed in a coherent and comprehendible format. When appropriate it should also discuss any data fitting done and how the 'goodness of fit' was determined.
    f. A discussion/conclusion section that articulates an evidence-based argument to support or refute the claim being investigated. When appropriate it should also include a comparison with results of other work and/or accepted values.
    g. A references/bibliography section citing other works referred to during the investigation and formatted in an appropriate manner.

2. Students' reports should adhere to conventions of scientific writing, such that they:
    a. Are organized logically, with effective transitions such that it flows as a single coherent 'storyline'.
    b. Use sentences and paragraphs that adhere to the usual conventions of communication.
    c. Contain minimal spelling and grammar errors.

Appendix 2: Computational Skills Outcomes (draft)

Computational skills – Draft Student Learning Outcomes

1. Students will be able to demonstrate mastery of technical computational skills by using appropriate software tools to:
    a. Process data.
    b. Visually represent data.
    c. Prepare professional documents and presentations.

2. Students will be able to demonstrate mastery of techniques in computational physics by:
    a. Translating a model into code.
    b. Choose scales and units that simplify coding.
    c. Subdivide a computational model into a set of manageable computational tasks.
    d. Choose appropriate algorithms and computational tools.
    e. Debug, test, and validate code.
    f. Extract physical insight from a computation.

Appendix 3: Research Skills Outcomes (draft)

Research Skills – Draft Student Learning Outcomes

1. Students will be able to plan a research study.
    a. Select a research topic that is feasible in terms of both resources needed and timescale needed.
    b. Conduct a literature search for previous work on chosen topic.
    c. Make a claim/prediction for the outcome of their study.
    d. Develop and document an experimental procedure.
    e. Write a research proposal encompassing all the above.

2. Students will be able to conduct a research study.
    a. Procure and test all needed equipment.
    b. Monitor their data as it is collected and make changes to the procedure if problems become apparent.
    c. Keep a notebook documenting their progress.
    d. Analyze data using appropriate software tools and statistical tests.
    e. Construct an argument, based on evidence, to support or refute their claim/prediction.

3. Students will be able to report on their research study in various formats.
    a. Write a report on their study in the format of a scientific journal article.
    b. Give a talk about their study in the format of a conference presentation.
    c. Prepare a poster that summarizes their research study.

Appendix 4: Oral Communication Outcomes (draft)

Oral Communication – Draft Student Learning Outcomes

1. Students will be able to give an oral report of an investigation that adheres to the following guidelines:
    a. Information is presented in a logical sequence that the audience can follow.
    b. Is of the appropriate length for the context in which it is made.
    c. Eye contact with the audience is maintained as much as possible.
    d. Is presented in a clear voice that is audible for all audience members.
    e. Seems well prepared and rehearsed.
    f. Is able to answer reasonable and relevant questions posed by the audience.

2. Any visual aids (slides) used to support the presentation should:
    a. Follow the flow of the presentation.
    b. Have a reasonable 'information density'.
    c. Include graphs that explain the data and support the conclusions drawn.
    d. Have minimal spelling and grammar errors.
    e. Include a bibliography and any appropriate acknowledgements.

Appendix 5: Experimental Investigation Outcomes (draft)

Experimental Investigation – Draft Student Learning Outcomes

1. Students will be able to conduct an investigation to gather evidence to support or refute a claim about the relationship between measurable quantities.
    a. Understand why a given experimental procedure will give evidence to support or refute a given claim.
    b. Conduct an investigation in accordance with a given experimental procedure.
    c. Recognize when an investigation is not providing necessary data and modify/adapt the experimental procedure as needed.
    d. Record observations/measurements in a coherent and comprehendible format.
    e. Conduct an investigation in a scientifically ethical manner.

2. Students will be able to appropriately manipulate uncertainties in measurements to determine the estimated uncertainty in a result derived from them.
    a. Understand the origin, significance, and importance of systematic and random uncertainties.
    b. Estimate/calculate uncertainties associated with particular measurements.
    c. Propagate uncertainties when using measured values in calculations of derived quantities.
    d. Understand the statistical significance of uncertainties quoted with measured and derived quantities.

3. Students will be able to construct graphs to show the relationship between measured quantities, use appropriate fitting techniques to determine a mathematical relationship between them, and extract derived quantities from the results of such a fit.
    a. Assign measured and controlled variables to appropriate graph axes and choose suitable axis scales for range of data to be plotted.
    b. (If appropriate) Plot data in such a way that a linear relationship would be expected if the claim is to be supported.
    c. Perform a linear least-squares fit to plotted data and use a statistical test to judge its 'goodness of fit'.
    d. Use the reported slope/offset of such a fit to calculate derived quantities and their associated uncertainties.

4. Students will be able to construct an argument, based on evidence derived from an investigation, to support or refute a given claim about the relationship between measurable quantities.
    a. Explain how the results of an investigation are consistent/inconsistent with a claim or with the null hypothesis.
    b. Judge the consistency of measured or derived quantities from different investigations, considering statistical uncertainties.
    c. Judge the consistency of measured or derived quantities to known values, considering statistical uncertainties.

Appendix 6: Alumni Survey Report 2018

Report on Physics Department Alumni Survey - 2018

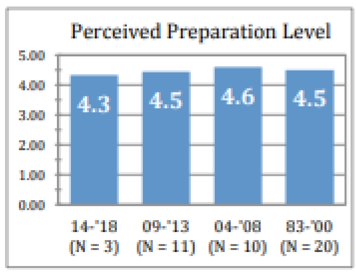
Introduction

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

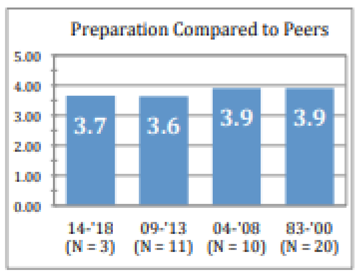
The greatest thing about my education in physics at TTU was that I graduated with a firm grasp of physics and mathematics and how to think rationally about problem solving as opposed to rote memorization. This was an excellent preparation for subsequent career where I have worked in a variety of areas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

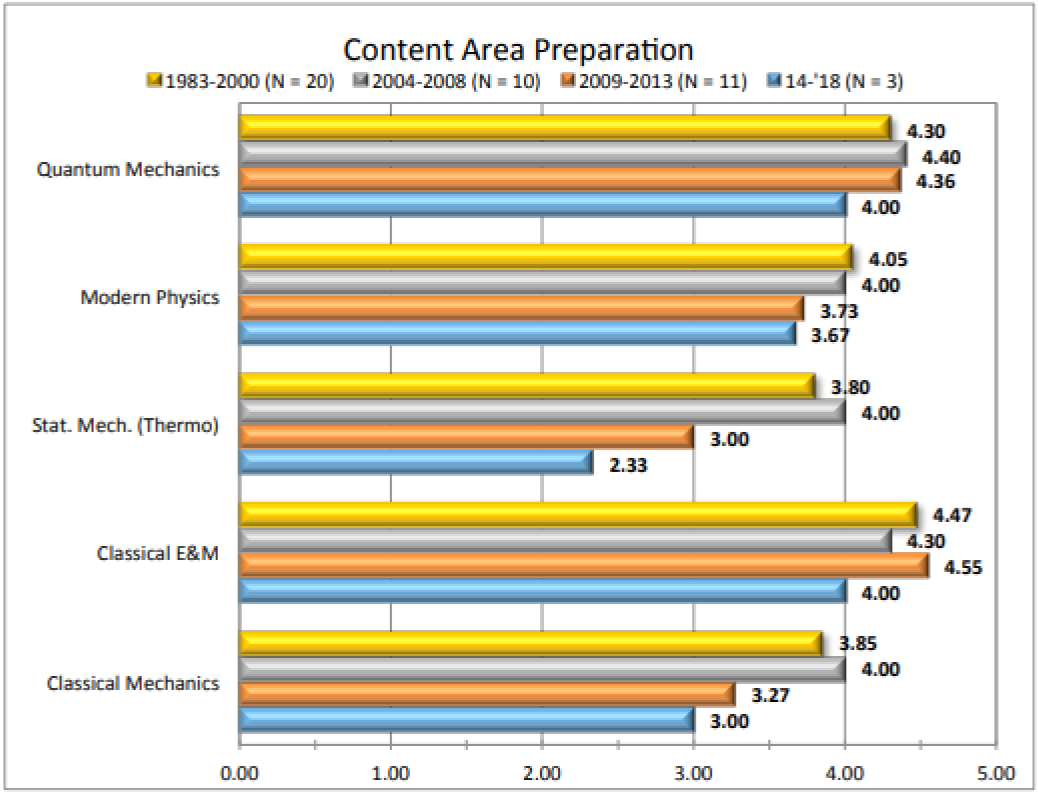
The following is from one individual:

> *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

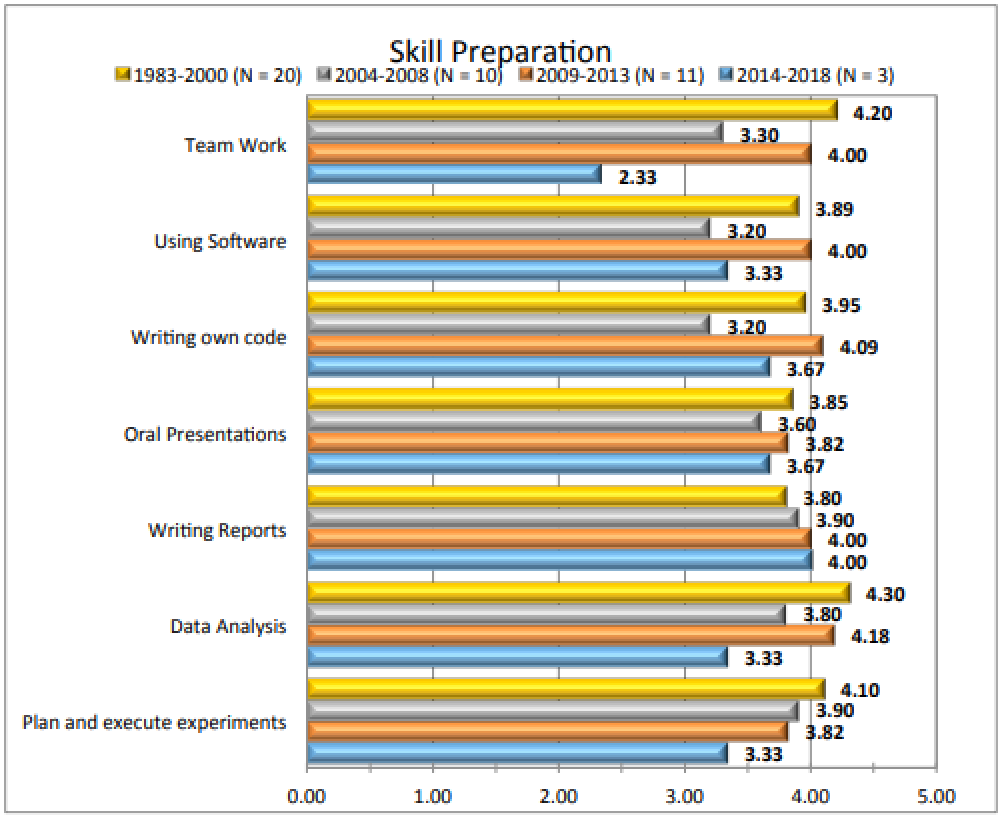
Linear algebra should have been a required course. Summer internships were THE BEST

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.

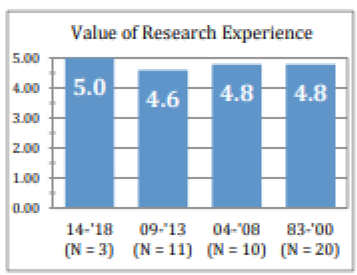
These results indicate that alumni continue to consider the overall level of preparation they received in particular skills to be good. However, the recent low rating for developing skills working as a team is of some concern. We feel that the increased emphasis on undergraduate research particularly 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.