Assessment of student learning

Physics General Education Courses
AY 2016-17

I. Introduction
As one of the central STEM disciplines, we provide a number of "service courses" to many students who are not our own majors. These range from required courses for engineering students to courses that fulfill the core science requirements for Fulbright and other colleges. These courses account for the majority of our SSCH.

Specifically, the following physics courses fall under the "general education" heading:

ASTR 2003/2001L, *Survey of the Universe* (introduction to astronomy for non-science majors).
PHYS 1023/1021L, *Physics and Human Affairs* (survey of physical ideas for non-science majors).
PHYS 1034, *Physics for Elementary Education Majors* (inquiry-based introduction to physics for future elementary school teachers; required by the College of Education).
PHYS 1044 and 1054, *Physics for Architects I and II* (a physics course specially designed for Architecture students).
PHYS 2013/2011L and PHYS 2033/2031L, *College Physics I and II* ("algebra-based" physics; taken primarily by students in the biological sciences).
PHYS 2054 and PHYS 2074, *University Physics I and II* ("calculus-based" physics, taken primarily by engineering students and students in the physical sciences).

II. Goals:

- For students in technical, STEM majors, our main goal is to provide them with the basic knowledge of physics that they will require later on in either their academic career (to succeed in more advanced courses) or in the workplace.
- For students in other majors, our main goal is to provide them with basic science knowledge in physics and an appreciation of the value and the methods of science.

III. Student Learning Outcomes
Students taking our service courses should be more scientifically literate and better able to understand and critically evaluate science issues as they affect society. In addition, students in a technical field should have the technical knowledge of physics and problem-solving skills necessary to do well in more advanced courses in their disciplines.

IV. Assessment of student learning

IV.A Direct methods

Score gains between pre and post tests: this assessment instrument is used in most of our service courses. For University Physics I and II, the standardized FCI (Force Concept Inventory diagnostic test) and CSEM (Conceptual Survey of

Electricity and Magnetism diagnostic test) are used. For Introduction to Astronomy, the standard is the ADT (Astronomy Diagnostic Test), developed by the Collaboration for Astronomy Education Research (CAER). For College Physics, and Physics and Human Affairs, in-house developed tests are used. In all cases, the Hake gain is computed.

Results for AY 2016-2017:

ASTR 2003/2001L, *Survey of the Universe*
Hake gain: Fall 2016: 22%. Spring 2017: not computed.

ASTR 2003H/2001M, *Honors Survey of the Universe*
Hake gain: Fall 2016: 59%.

ASTR 2003/2001L online sections, *Survey of the Universe*
Hake gain: Fall 2016: 42%. Spring 2017: 48%. Summer 2017: 44%

PHYS 1023/1021L, *Physics and Human Affairs*
Hake gain: Fall 2016: 29%. Spring 2017: 42%. Summer 2017: 46%.

PHYS 1023/1021L online sections, *Physics and Human Affairs*
Hake gain: Fall 2016: 29%. Spring 2017: 37%

PHYS 1034, *Physics for Elementary Teachers*
Hake gain: Spring 2017: Section 001: 65%. Section 002: 60%.

PHYS 2013/2011L and PHYS 2033/2031L, *College Physics I and II*
Hake gain: Fall 2016 (College Physics I): 19%. Spring 2017 (College Physics II): 18%

PHYS 2054 and PHYS 2074, *University Physics I and II*
Hake gain: Fall 2016: UPI: 42%. UPII: 30%. Spring 2017: UPI: 46%. UPII: 31%.

IV.B Indirect methods

- Feedback from instructors of more advanced courses or academic advisors in the students' colleges.
- Feedback from other sources (e.g., MCAT instructors)
- Feedback from students.

IV.C Data collection and analysis
The pre and post assessment tests are collected every semester and the results are reported to the Department's vice-Chair. This year we were able to collect data on all of our GE courses with the exception of ASTR 2003 in Spring 2017 (this section was taught by an instructor unfamiliar with the process) and PHYS 1044/1054 (*Physics for Architects I and II*). We are creating a Service Courses Committee that will collect this information in the future as well as develop feedback mechanisms from other sources,

and make recommendations for assignments or curriculum changes to the rest of the department.

IV.D Use of results

The data collected above are used in many ways: at the individual instructor level, at the curriculum level, and when considering teaching assignments, for instance. In what follows, we describe briefly the conclusions we have drawn from the results presented above, and the actions we have taken in response, where appropriate.

1. Hake gain results: although this has become, by now, a standard measure of learning gains, its significance is somewhat hard to quantify, since it depends on a number of factors, including the nature of the course considered and the method of instruction. Studies such as R. R. Hake, Am. J. Phys. 66, 64-74, 1998, indicate that for introductory Physics courses covering primarily classical mechanics, and making use of the FCI test—courses such as College Physics I and University Physics I in our program—"traditional" teaching methods typically result in a Hake gain of about 23%, whereas gains on the order of 48% are achievable with "interactive engagement" methods.
2. For astronomy courses, typical gains when applying the ADT are reported to be 20-30%, depending on course components used such as lecture, laboratory, and discussion sessions (Brogt et al. 2007, Astronomy Education Review, Vol. 6, Issue 1.) We include both a lecture and laboratory component. In recent years, we have made an effort to align our laboratory curriculum with that of the lecture with the aim of improving learning outcomes and student satisfaction. Results are as yet unclear. In fall 2016, our regular section obtained typical gains (22%) while our honors section reported gains of 59%. The difference may be explained by how the test was administered. In the honors section, the post-test was given as part of their final exam, perhaps motivating students to try their best on the post-test, resulting in much higher gains.
3. At the curriculum level, we have spent many years perfecting our approach to the introductory physics courses, UPI and UPII, based on the Hake gain data as well as other empirical data, and the results of physics education research (in some cases conducted "in-house" by Drs. John and Gay Stewart). The result has been a curriculum that, while still continually being "tweaked," boasts of substantial student learning gains and has been also validated by feedback from the engineering college, which claims that their students perform better in their advanced courses, after having taken our introductory physics sequence, than they did several years ago. The success of the U of A Physics department in revitalizing the Physics curriculum has been repeatedly recognized nationally.
4. The UPI and UPII data seemed to indicate that online students of these courses do consistently worse than face-to-face students by a variety of measures, despite having otherwise entirely comparable homework, test and laboratory experiences. Accordingly, we have phased out those online courses, as well as the College Physics ones. On the other hand, online students of *Physics and Human Affairs* (PHA, our general science core offering) did not seem to suffer from this problem. We have continued to offer an online section of PHA with Hake gains that mirror our on-

campus offerings extremely well. We have now developed an online version of ASTR 2003 (*Survey of the Universe*.) Hake gains for the online version have ranged from 41 to 53%. Again, these values are higher than those typically reported and are likely due to the post-test being administered as part of their final exam.

5. We continue to struggle with the learning outcomes in our College Physics sequence. We assigned the course to an instructor with a biophysics background after receiving feedback concerning the physics knowledge of our students as applied to the MCAT exam. This was in hopes of improving our learning outcomes which would then result in better scores for our students on the MCAT. The instructor in question struggled with the course and has since been let go. We have assigned a veteran instructor with experience in active learning techniques to CP I in Fall 2017.