Northern Arizona University

Annual Report on Degree Program Assessment of Student Learning

University Assessment Committee

Office of Academic Assessment

Purpose: The purpose of the *Annual Report on Degree Program Assessment of Student Learning* is to provide information about progress in assessment efforts for each degree program within your academic unit. Only one report is requested of each academic unit, as this report will accommodate multiple degree plans. (You can still submit separate reports if you prefer.) The report will be made available publicly at the Office of Academic Assessment website and will be available to appropriate accrediting agencies. It is recommended that your unit use your assessment report and results to *celebrate achievements of student learning* as well as to *identify potential areas for future curriculum improvement*. The University Assessment Committee will review your report to provide constructive feedback, as well as to identify particular academic units for potential assessment awards and/or mini-grants to support continuing assessment efforts.

Please email this completed form as an attachment to ***d-oaa@jan.ucc.nau.edu***.

CONTACT INFO:

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Degree Program(s) reported here: Physics, Astronomy, BSED Physics

ASSESSMENT REPORT:

Instructions: Please answer the following **five** questions to the best of your ability for each degree program offered within your unit. *You may use the table provided on the next page, or you may create your own report format*.

1. Summarize your **assessment activities** during the past year for each degree program. *(e.g. faculty discussions, new survey design, data collection, revised assessment plans or learning outcomes, etc.).*

The purpose of the Department of Physics & Astronomy's Assessment Program (AP) is to provide a usable tool for our faculty to reflect upon and continuously improve the effectiveness and quality of our teaching. Many kinds of data from students in each of our degree programs has been and will be regularly gathered and analyzed to provide information regarding the effectiveness of each program's curriculum and instruction. Our faculty then uses this AP information to inform decisions regarding potentially beneficial adjustments to those programs.

In an attempt to foster a mastery of learning within each student, continuous formative and summative feedback will be given pertaining to how their progress balances with faculty expectations. In addition, our faculty will undergo scrutiny, both from within and without, to ensure that we are providing the curriculum and environment wherein students may continuously improve their learning.

The purpose of this AP report is thus two-fold: To provide an opportunity for faculty in our department to gather the appropriate resources and perform the requisite self-reflection that is the sin-qua-non of a positive-feedback assessment process, and to report on our progress and outcomes.

To be honest, much of our faculty's self-reflection occurs at the end of each semester, when there is time to assess what has transpired during the previous term and exams and grades may be inspected. The fact that this report is typically to be compiled prior to the end of the spring term, and into the week of finals of that term, means that, essentially, we are reporting on the results of only a single semester's worth of analysis (Fall 2006) subsequent to our department's establishment of this plan with your office earlier last year.

An overview of the Department of Physics & Astronomy's AP plan, together with specific Learning Outcomes and a summary of our 2007 efforts, follows. It should be said that our department has several degrees that substantially overlap and so a very similar AP will be involved and reported on each time.

We also provide a detailed summary of our department's AP activities that are not tied to our degree programs because they reflect on our efforts to make AP more comprehensive within our department.

The Department of Physics & Astronomy has collectively identified five specific *Learning Outcomes* that we will attempt to measure, analyze and improve. Students will:

- Understand the theoretical basis of the content in their major
- Possess laboratory procedural competence
- Possess critical thinking skills
- Possess oral communication skills
- Possess written communication skills

In addition, as a result of our current departmental assessment program, we have tentatively identified a sixth *Learning Outcome* that is being considered for attention:

- Teamworking Skills

In order to effect this analysis, we have identified five specific aspects for each *Learning Outcome* that will be identified. Specifically, these include:

- Identifying the course(s) where the specific *Learning Outcome* will accrue
- The choice of evidence
- The method(s) of evidence collection mechanism that will be used
- What procedure(s) will be brought to bear to objectively analyze this evidence

- And, perhaps most importantly, what feedback procedure(s) will be put in place to ensure that continuous improvement in the effectiveness of each program's curriculum and instruction will result.

2. Describe specific **assessment findings** related to the **learning outcomes** assessed for each degree program, including any pertinent context surrounding the findings. Please include the **learning outcomes themselves**. *(e.g. 77% of seniors performed at the "proficient" level of competency in problem solving, which is where we aimed to be this year using a new scoring rubric…)*

(1) Performance on the *Force Concept Inventory* (FCI), both pre- & post-. This is an exam developed by ASU's Dr. David Hestenes, et. al., and has been given to hundreds of thousands of physics students at the high school and introductory college level during the past decade. Our department has placed this instrument on-line, and each student can take the exam outside of class, both at the beginning and end of the semester, and have their improvement analyzed. It is IRB-approved. The results can easily be compared across both time and 'instructor of record'.

The Force Concept Inventory (FCI)

In addition, a standard assessment instrument called the Force Concept Inventory (FCI) is given to all students in our introductory algebra-based (PHY 111) and calculus-based (PHY 161) physics classes. Results from this and previous semesters are also shown in the FCE Tables below. This record shows a rather low score for two of our courses this year, and our faculty have been informed of this and are currently in discussion as to how to address the issue. For PHY 111, that particular (visiting) professor will no longer be teaching in our department, and for PHY 161, the low score on this diagnostic likely reflects the greater emphasis that this particular professor has on the overall theoretical development of each topic rather than the particular manner in which the FCI seeks to measure a facility with those topics. We continue to discuss this, however.

Please note that although PHY 111 is not part of any of our degree programs, we nonetheless use this assessment instrument here, and use other instruments on other non-degree (service) courses as part of our department's overall assessment plan.

The current professor in our second semester of algebra-based introductory physics (PHY 112) has also decided to institute substantially common future exams and final exams. The particular purpose of this investigation was specific to this course, and lay in the assessment of a new, on-line homework tutorial system. The question that is raised is whether test performance has changed after the homework system was installed, and if performance was enhanced due to greater accountability. One indicator will be the exams and the final exam.

Homework tutorial summary: 24 homework assignments covering a total of 125 questions and problems were assigned, and every section of every problem was graded. The class-wide average, for the semester, was 79%.

Details for the FCI Analysis (A Standardized Instrument)

PHY 111 Semester	**Instructor**	**FCI post**
Sp 2005	Cole	61 %
Sp2006	Cole	55 %
Fall 07	Wilson	42 %

Nationwide averages for the FCI:
Pre is about 26 %, with 20 % (6) being the baseline (random) score.
The nationwide, post average of many thousands of university students is 62 %.

PHY 161 Semester	**Instructor**	**FCI post**
Fall 03	Cole	68 %
Spring 06	Cole	64 %
Fall 07	Bowman	42 %

(2) Collection of "benchmark" data from in-class exams, quizzes, homework and lab reports, and final exams. In particular, several professors are considering using one or more identical questions on, for instance, a final exam. In this way, student performance could be directly compared across both time and 'instructor of record'.

Benchmark Question AP (Assessment Program) Data

Several classes have instituted so-called *benchmark questions* to assess the on-going consistency of effective instruction. These are questions that will be asked on the final exam in each future semester or year that the class is taught. A direct comparison of student performance is thus possible, and the instructor of record can then use that data in an overall assessment of their personal instruction. In each case, the particular question was chosen to represent information or skills that each student is expected to display by the course's completion; regardless of who is the instructor of record.

These data will be saved and used in subsequent semesters. However, as this is the first time such benchmark questions have been used, we report here on a mere summary of results. In other words, no comparisons are possible.

<u>PHY 471</u> (Quantum Mechanics): A 4-part *benchmark* question was asked and each student was required to write out a complete answer. The average of this section was 90%.

<u>AST 280</u> (Intro to Astrophysics): A 4-part *benchmark* question was asked and each student was required to write out a complete answer. The average of this section was 88%. There was one score of zero, one score of 20%, and 13 perfect scores.

PHY 441 (Thermodynamics and Statistical Mechanics): A very difficult, 7-part *benchmark* question was asked and each student was required to write out a complete answer. The average of this section was 60%, with no perfect scores. This course has been chosen to illustrate, in depth, a specific example of how our department establishes and uses benchmark questions. The following is a question that will appear on our final exams in the future. It is given with a rubric for establishing point values for each part of the question.

7) Polymers, like rubber, are made of very long molecules that tangle into a configuration that has lots of entropy, S. A crude model of a rubber band contains N links, all of equal length L, which can only point either left or right (2 possible states). The total length of the band is thus the net displacement from the first to the final link. This is a waaaaay cool problem, and I will help you through it step by step. Derive Hookes's Law, and find the "elastic entropy"!!! (25 points)

a) Find an expression for the entropy of the rubber band in terms of the total number of links, N, and of the number that point 'right', N_{right}. Hint: The multiplicity is as straight-forward as you would hope, and use Stirling.

This part is worth 5 points, and the reader will be spared the details of the solution.

b) What is L in terms of N and N_{right}. In other words, eliminate N_{left} from this expression.

This part is worth 2 points, and the reader will be spared the details of the solution.

c) For a 1-dim system like this, we can make an analogy with P and V for a 3-dim system: V becomes L, and P becomes F. Take F, or the tension force, if you will, to be positive when the rubber band is pulling 'back' (inwards). What is the thermodynamic identity of this system—in other words, what is the re-written version of the 1st Law? Comment!

This part is worth 3 points, and the reader will be spared the details of the solution.

d) Using this identity, you can now find an expression for F in terms of a derivative involving S ($dU = 0$). Now expand this partial derivative by putting in the following term, $\partial N_{right} / \partial N_{right}$ which is obviously unity and does not change the value of the derivative. Using your result from part (b), you should now have a (1/2L) term. Use part (a), and apply the derivative w/r/t N_{right} now, and not L, to find the tension force = $f(L, T, N, N_{right})$.

This part is worth 5 points, and the reader will be spared the details of the solution.

e) Show that when $L \ll NL$, F has a very familiar form. What is the value of the spring constant, k?

This part is worth 2 points, and the reader will be spared the details of the solution.

f) Discuss the dependence of the tension force on T. If you increase the T of a rubber band, does it (tend to) expand or contract? Comment!

This part is worth 4 points, and the reader will be spared the details of the solution.

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g) We did not find the total S above; we ignored the vibrational entropy, which depends on E but not L. Stretch and contract a good rubber band, and use your lips as a probe. Comment!

This part is worth 4 points, and the reader will be spared the details of the solution.

Benchmark Question Details:

In order to facilitate future direct student performance comparisons, several of our courses use a standard assessment instrument or question on the final exam. For instance, the current professors in our introductory quantum mechanics (PHY 471), and in PHY 441 (Thermodynamics and Statistical Mechanics) class have decided to institute a common question on all future final exams that represents a skill set that every student in this class should have regardless of which faculty member is the instructor of record. This will soon be true in other classes.

Assessment of this data will occur at the end of the second semester of use, so that comparisons can be made; in the Fall of 2007. As a caveat, this data from our upper-level courses must be treated with some care for two reasons: They involve the statistics of small numbers, and the quality of our students can vary quite substantially from year to year (class to class).

(3) The Graduate Record Exam (GRE) in Physics. This exam is administered outside of this department. It is scored and normed nationally, and gives both the individual student, and the department as a whole, an objective, impartial data point on the preparedness of that student to enter graduate school in the field of physics when compared against all other incoming graduate students across the country.

This instrument will be used formally in next year's assessment program, in order to give several years to compare. Some work will have to be done to analyze the date to see if any department-related variables are directly linked to student performance.

(4) Most of our assessment findings are applied to all our degree programs, which are very similar in scope. However, our teacher training program requires some additional tools specific to that program. One of these is the student teaching evaluation which is done by a faculty member in either our program or the Center for Science Teaching and Learning (CSTL). One of these forms is shown below (with the student's name deleted). A wide variety of areas are evaluated and scored in order to judge the potential effectiveness of the student in the classroom. As the numbers in any given semester may be small, we will use these over the next three years to develop an idea of norms and key areas for improvement.

NORTHERN ARIZONA UNIVERSITY
College of Education
Field Experience

STUDENT TEACHING EVALUATION: _____ **MID-TERM** _X_ **FINAL** (please check appropriate)

Student Teacher: ____________________ Social Security #: ____________________
Cooperating Teacher: David Thompson Cooperating School: Coconino
Subject/Grade Level: Physics School District: FUSD

Instructions: On the form below, circle the number that typifies the level of performance of your student teacher. Please comment on as many areas or skills as possible. Please use the following numerical classification: 0-Not applicable OR Not observed; 1-Unsatisfactory; 2-Below average; 3-Average; 4-Above average; 5-Outstanding. Press firmly to ensure legibility on all copies. After completing this form, please keep your copy, then give the appropriate copy to the student teacher.

Classroom Personality

Is confident when teaching.	0 1 2 3 4 5
Is perceptive of students' problems.	0 1 2 3 4 5
Uses reinforcement consistently.	0 1 2 3 4 5
Motivates students through encouragement.	0 1 2 3 4 5
Has disciplined control of the students.	0 1 2 3 4 5
Responds professionally to crises.	0 1 2 3 4 5

Communication Skills

Conveys an accurate picture of students' performance.	0 1 2 3 4 5
Uses proper English.	0 1 2 3 4 5
Uses test data to plan instruction.	0 1 2 3 4 5
Defines and prioritizes goals for instruction.	0 1 2 3 4 5
Selects methods and materials that are consistent with objectives.	0 1 2 3 4 5
Adapts media and materials to fit the needs of students.	0 1 2 3 4 5

General/Personal

Accepts evaluative feedback and adjusts behavior accordingly.	0 1 2 3 4 5
Recognizes and corrects errors.	0 1 2 3 4 5
Demonstrates initiative.	0 1 2 3 4 5
Fulfills requirements of attendance and punctuality.	0 1 2 3 4 5
Maintains an appropriate appearance.	0 1 2 3 4 5
Works well with colleagues.	0 1 2 3 4 5
Communicates professionally with parents.	0 1 2 3 4 5

Instructional Skills

Uses appropriate vocabulary when giving directions.	0 1 2 3 4 5
States expectations to students.	0 1 2 3 4 5
Presents concepts clearly.	0 1 2 3 4 5
Uses time efficiently.	0 1 2 3 4 5
Focuses students' attention on task.	0 1 2 3 4 5
Models basic skills appropriately.	0 1 2 3 4 5
Uses manipulative materials.	0 1 2 3 4 5
Encourages active learning.	0 1 2 3 4 5
Varies instructional methods.	0 1 2 3 4 5
Provides appropriate lessons.	0 1 2 3 4 5
Informs students of errors.	0 1 2 3 4 5
Implements efficient transitions between activities.	0 1 2 3 4 5
Prepares and has available all necessary instructional materials.	0 1 2 3 4 5
Maintains accurate records regarding students' learning.	0 1 2 3 4 5
Adjusts physical environment to meet the needs of students.	0 1 2 3 4 5

Comments

Please use the following space to describe your student teacher's performance of assigned duties and personal qualities related to teaching.

Nice board work - very clear presentation of difficult concepts

Evaluation given by (check one):

_X_ UNIVERSITY SUPERVISOR
or
_____ COOPERATING TEACHER

[illegible] 12/12/06
Evaluator's Signature Date

Student Teacher's Signature Date 12/12/06

RETURN TO: Coordinator of Student Teaching
College of Education – Student Services
NAU Box 5774
Flagstaff, AZ 86011

COPIES: White: Student Teaching Office
Canary: Cooperating Teacher
Pink: Student Teacher
Goldenrod: University Supervisor.

(5) The department chair conducts exit interviews with each graduating student in the department. We also have periodic alumni questionnaires that, among other things, ask how their experiences here prepared them for both graduate school and the workplace. The questions are almost always the same and can be compared with students from previous semesters. This program is described further in the next section.

(6) Various professors and courses call for the student to present their results for an end-of-term project. This evaluation is subjective and is almost surely not compared with students from previous semesters.

3. Describe how assessment **feedback** has been provided to students, faculty, and staff.

The primary method for communicating with the students is currently the exit interview, which is now described;

Our exit interviews of all graduating seniors consist of a very thorough set of 39 questions which solicit their honest and anonymous evaluation of every aspect of our department's programs, faculty and resources. We have conducted interviews in each of the past semesters stretching back for more than a decade. Although a comprehensive search for trends or patterns cannot be reasonably conducted for all 39 questions, the department was very concerned about several critical issues, and so the data was initially mined for what we felt was two critical pieces of information: "Overall quality of instruction" and "Quality of resources".

Overall quality of instruction

Nearly every student talked about our department's good or excellent quality of instruction with only one caveat: Students complained that the large size of the intro courses made both learning more difficult and the overall quality less apparent.

Without exception, students who indicated that they had attended other universities and then transferred to NAU spoke about the relative excellence of our faculty and praised our availability and concern for their true growth.

A few students made comments about how we handle the dichotomy of where students go after they graduate (industry or grad school), but most felt like students with either interest received the preparation required for success in either field and that resources and advice was available and appropriate.

A few of our faculty were consistently named as being good or influential, but no faculty member was consistently named as being poor.

Students liked the open and friendly atmosphere of the department and uniformly felt like all faculty were approachable and available.

Some students over the years talked about one or two specific courses and how the curriculum or prerequisites could be changed to benefit them. This feedback was taken into direct consideration in our alterations, in 2006, of the specific order and semester of offering of several of our courses. This new structure seems to serve our students better and will be continued.

Some students indicated a need for increased internship and research activities. As a response, the department is actively in communication with the Flagstaff Medical Center and W. L. Gore to arrange for paid intern experiences and is working to enhance our existing ties with Lowell, the USGS and the Naval Observatory Facility for mentoring and research experiences for our students.

We will also be initiating a discussion section in the fall with our Society of Physics Students (SPS) organization to gather feedback on curriculum and program issues. We will charge the assessment committee with incorporating this feedback into departmental recommendations.
In our first faculty meeting of the fall, the assessment committee will give a presentation on its findings from the previous year. At that time, we will also entertain suggestions regarding all student-related issues, including curriculum, advising, etc. We find that each faculty member has thought a great deal about improvements which might be made and at this time we will give these ideas to the curriculum committee with the charge of reviewing possible changes and improvements. As more data becomes available on our benchmark questions, we will initiate faculty discussions on improving student understanding, and on finding the best ways to measure that understanding.

4. In what ways have you **used assessment findings** to celebrate student achievements and/or to improve the curriculum this past year? *(e.g. prizes to students, hosting student parties, changes to curriculum, student projects, learning goals, assessment strategies, etc.)*

Most of the changes we enact in our programs are curricular. We are always gathering feedback in a variety of ways from faculty and students. In this way, we initiated our computational physics courses several years ago, using feedback from employers and faculty to determine that a specialized computational course in our department was necessary. From student comments, especially from exit interviews, we determined that improvements in our infrastructure were needed. The next section details these issues.

Quality of resources

This is an area that receives some amount of criticism. Our undergraduate lab facilities and our Junior-level “Advanced Lab” have equipment that is functional but dated. Students felt like resources needed to be upgraded in these areas, but available funds continue to be primarily used to upgrade computer-based resources. We have been engaged in a debate about how to proceed, and are currently in the process of upgrading ‘one lab at a time’ due to funding limitations and due to the fact that new equipment often requires that lab experiments and manuals be re-written. Both of these require that faculty be engaged and willing to devote extra time without additional compensation or release time, but all of our faculty have stepped up to some extent to make this happen. Without a doubt, however, it will take more time and more funding to bring our equipment up to the level that Chemistry, Biology and Biochemistry continue to enjoy.

As a direct result of exit interview responses by students and the issues raised by the relative lack of modern equipment, a lab fee has been requested and granted for this course (PHY 333-W; Advanced Lab) so that funds may be used for just that purpose.

There are several conclusions and action items that we have decided upon based upon our internal assessments.

Degree Program-Relevant Conclusions:

A1) The employment and graduate school acceptance of our majors continues to be strong, and their feedback indicates a steady increase in their appreciation for the education they received.

A2) Our support of undergraduate research is very strong and continues to have a very positive impact both in their education here and in the increased opportunities afforded to them later.

A3) Our department continues to innovate and advocate the use of technology in the classroom, such as classroom response systems and web-based homework tutorials. These tools are working well and appear to improve student-teacher interaction and accountability. We affirm our position, however, not to promote or provide distance delivery courses.

A4) Our writing intensive course (PHY 333-W) has perhaps received the most scrutiny and improvement in recent years, and continues to pose a challenge as faculty struggle with equipment and students struggle with improving their communication skills. We have learned the importance of creating smaller, more achievable goals that are distributed throughout the semester, so that formative feedback can be given and incorporated into each subsequent effort.

A5) Our precise schedule of completion for some courses has been changed in our degree plans to respond to a desire by students to take certain courses that were heretofore difficult because of scheduling conflicts. We have modified the curriculum slightly to accommodate this transition and feedback so far is very positive.

5. Describe any changes to your assessment plans, or any challenges or educational experiences with the **assessment process** this past year that you would like to share.

B1) Our current assessment protocols are both necessary and sufficient to address the needs of our department's staff, faculty and students. We will continue to emphasize and promote open communication lines and continue to meet regularly to discuss these and other issues.

B2) A general consensus prevails that our recent loss of a faculty member whose expertise lay in computational physics was detrimental to our stated intention of infusing all junior and senior-level classes with more computer-based, computational problems, but that our new assistant professor hire will specifically address this deficiency.

B3) Our student-based Society of Physics Students (SPS) organization continues to thrive even as they must essentially re-invent themselves each year as their most senior participants graduate and leave. Through faculty guidance, they have learned that to be effective, they must continue to meet regularly, invent revenue-generating mechanisms to fund their educational outreach and field-trip activities, and maintain a large officer pool so that duties can both be shared and mentor-apprentice relationships fostered.

B4) As the weather becomes even less predictable, more computer-based astronomy labs need to be created due to poor outdoor observing conditions. Our astronomy faculty has taken these increased duties upon themselves naturally and without asking for release time.

a. *Please submit any **revised/updated assessment plans** to the Office of Academic Assessment along with this report.*