The Student Conference: A Model of Authentic Assessment

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Abstract—**In the global marketplace, the ability to communicate, both orally and in writing, is a skillset demanded by employers. Unfortunately, typical academic exercises that involve written and oral communication are often just that … academic exercises. To provide a more authentic and robust experience, a student conference activity has been developed for use in a second-level physics course entitled Physics for a New Millennium (PNM) at American University (AU). This activity involves writing a formal research paper using professional guidelines. In addition, students present their research paper during a class event modeled after an actual professional conference. A focus of this paper is to discuss the assessment strategies developed for the conference paper activity. A major goal of the assessment strategies designed for the conference paper and the associated presentation is to better capture (and then assess) what students are actually learning in the course. This paper will provide an overview of the student conference paper activity with emphasis on its value as an alternative assessment tool. To that end, a synopsis of how the conference paper activity has been designed will be shared. This synopsis will begin with a general discussion of assessment, assessment methods, and the "language of assessment." Following this synopsis a model of non-traditional assessment using the student conference paper will be highlighted. Subsequently a description of the course curriculum and the specific structure for the writing activity will be outlined as they relate to the learning outcomes for the course. Shadowing the presentation of the course-specific learning outcomes, a description of the strategies used to uncover student learning will be shared. These strategies provide an opportunity for multiple assessment "snapshots" to be made throughout various phases of the learning process. To illustrate these snapshots, examples from actual student work will be presented and discussed. The assessment strategies developed for the student conference paper can be used as an alternative, or as a supplement, to more traditional pencil and paper examinations, quizzes, and homework assignments. Whether used as a stand-alone assessment tool or coupled with more traditional measures, the model presented here can provide an enhanced and more authentic way to capture what students are actually learning while the learning is taking place.**

Index Terms—**Alternative assessment, assessment models, authentic assessment, formative assessment, learning goals and objectives, learning outcomes, student writing, written and oral communication.**

I. INTRODUCTION

How can we really assess what students are learning? What can we learn from traditional assessment measures? Do traditional assessment measures really provide us with a robust picture of what students are learning throughout all facets of the learning process? Questions such as these provide the motivation for this paper.

Studies on teaching pedagogies have clearly demonstrated that traditional techniques often put students in a role of passive rather than active learning [1 – 5]. Furthermore, more traditional methods have been shown to be very inadequate in terms of promoting deep learning and long-term retention of important concepts [6 – 9]. Students in traditional classrooms often acquire most of their knowledge through passive classroom lectures, textbook reading, and the internet. Passive learning routinely results in students merely trying to learn and regurgitate what the teacher and textbook are telling them. A discouraging fact is, after instruction, students often emerge from our classes with serious misconceptions [10 – 16]. Writing can be used to effectively help students confront their misconceptions. In addition, formal writing strategies can provide essential "snapshots" to help uncover what students are really learning as the learning is taking place.

Traditional examinations and quizzes merely provide an assessment marker after a segment of material has been covered in class. While important as a point for charting progress, these forms of assessment do little to uncover what is actually taking place in the mind of the learner. Astin [17] argues that as professors, we may think that we've given a very stimulating and thought-provoking lecture, without ever really knowing how much of it was actually understood by the students, how much was retained, or whatever other kinds of effects it may have had on the students. While traditional examinations and quizzes may provide us with some information about what students are learning, this more summative type of feedback really comes a little too late. A carefully crafted writing activity or set of activities can provide a more formative and authentic assessment of student learning; and, give students and professors time to correct any misconceptions or flaws in reasoning as the learning is ongoing. The particular writing-based assessment activity to be showcased in this paper was developed for use in a second-level physics course for non-majors. Before discussing the writing activity, some details about the course setting will be presented.

II. COURSE STRUCTURE AND SETTING

A second-level physics course for non-majors entitled Physics for a New Millennium (PNM) at American University (AU) serves as the setting for this project. Designed by the author, this course is taught in an interactive studio/workshop format. Numerous projects and studies within the domain of Physics Education Research (PER) have pointed to the importance and value of using a learner-centered, activity-based environment. A significant outcome of these and other PER studies is; in comparison to more traditional instructional strategies, student conceptual understanding and problem-solving ability is enhanced within an activity-based learning environment [18 – 25].

PNM is a course that many students take to satisfy the university's General Education requirements towards graduation. A unique element of the PNM course is its active learning format along with its focus on student writing as an alternative method of assessment. This form of assessment is in contrast to more conventional classroom measures and to numerous research-based normalized tests and surveys such as the Force Concept Inventory (FCI), the Force-Motion Concept Evaluation (FMCE) the Mechanics Baseline Test (MBT), and others [26 – 31].

All students enrolled in PNM have taken a first-level introductory physics course with a laboratory component. The curriculum for the second-level PNM course includes the following topic areas (which are quite typical in any second-level course): sound and waves, electricity and magnetism (E & M), light and color, optics, and (time permitting) introductory modern physics. The course consists of one 75-minute period each week where course content is delivered in an interactive lecture format. The second weekly period is 150 minutes in length. The double-length period is designed to give students a good deal of time to perform hands-on activities and experiments within a team-based environment. Because of the unique nature of the course, class size is limited to 16 students.

The non-traditional design and structure of the PNM course lends itself well to the development and use of alternative and perhaps more authentic assessment measures. Before discussing the assessment measures developed for use in the PNM course, a brief overview of the language of assessment will be shared. The intent of this overview is to provide a framework for assessment development and use at the individual course level and beyond.

III. LANGUAGE COMMON TO ASSESSMENT

At the heart of assessment is **student learning**. Within the academy, whether at the course-, department-, program-, or institution-level, assessment is the name of the game. Institutions are responsible for providing assessment data, results, etc. to whatever accreditation agency or body is applicable. As faculty member, it is easy to sometimes think of assessment as "something we have to do for accreditation purposes." While this is certainly a true statement, assessment should be much more than that. If properly framed, assessment plan can serve a multitude of purposes.

The focus of any plan should be the **assessment of student learning**. As part of this plan we need to ask: *Are our students learning what we intend for them to learn; and, what evidence do we have to document that this learning has actually taken (or is taking) place?* While on the surface of things this might seem like a relatively easy question to answer. In practice, however, providing evidence of student learning takes careful thought and planning in order to create a blueprint that does more than just satisfy an institution's need for some data for their report to an accrediting body.

The language of assessment includes such terms as **learning goals**, **learning objectives**, and **learning outcomes**. Goals and objectives are very similar to one another. They essentially describe the intended scope and expected results of a teaching activity, course, or program. **Goals** express intended outcomes in *general* terms and **objectives** express them in *specific* terms [32]. A **learning outcome** refers to a statement that describes what the learner is to have achieved and can reasonably and reliably demonstrate by the end of a teaching activity, course, or program.

Measures to assess student learning typically fall into one of two categories: *direct* or *indirect*. A **direct measure** is one that "directly" evaluates student learning [33]. Direct measures include the use of actual student work and include items such as an

- exam or quiz,
- class assignment, project, report, etc.
- work-related task,
- interaction with a client (perhaps as part of an independent study or cooperative learning experience), or a
- musical or other performance.

It is not sufficient to simply use grades alone as a measure of student learning. Instead what is needed is a set of criteria used in the assessment, a clearly-framed analysis and discussion of results, and a feedback loop that can be linked to a specific department's program, general education, and/or the decision-making process at the institutional level. Simply reporting that X% of the students got A's, Y% got B's, etc. is not a sufficient direct measure of student learning.

An **indirect measure** of student learning is based on a report of perceived student learning [34]. Indirect measures can also provide information regarding how what a student has learned is valued by a specific stakeholder or set of stakeholders. For example, this information might come in the form of a report from a supervisor on an independent study project, a cooperative learning, or other work experience. Indirect measures provide additional information but are not as strong as direct measures in terms of truly capturing what a student has learned. In addition, indirect measures often involve an interpretation of an evaluation by a supervisor, or an assumption regarding just what the evaluation represents.

The next section provides a brief description of the PNM course format. Included within this description is a presentation of the learning outcomes for the course along with the associated direct measures used to assess the learning outcomes.

IV. THE PNM COURSE FORMAT

Throughout a given semester, students in the PNM course have an opportunity to perform numerous hands-on activities designed to give them multiple opportunities to interactively engage with the course content. The topics explored within the PNM curriculum are fairly typical to any second-level introductory physics course and were briefly presented earlier.

The format for the PNM course stresses teamwork throughout all activities. Some activities are structured in a more traditional lab format, while many are structured in

Figure 1. Teams of students working with electric circuits.

Figure 2. Student teams investigating standing waves on a string.

such away so as to provide students with an opportunity to pursue inquiry and investigation using a variety of techniques. Whether students are investigating sound waves in air, building a motor, or learning about light and color, a team approach takes center stage. Fig. 1 and 2 provide an illustration of how the classroom is structured based on a team environment.

Regardless of the activity, the class as a whole functions as a team. The team does not move on to a new activity until all class members have completed a particular activity. The end result is as individual teams of students finish an activity, they move into the role of teaching assistants, working to ensure that all of their classmates have fully completed a task or set of tasks. In this way, everyone's class time is utilized to the fullest extent possible. In addition, moving into the role of teaching assistant really aids students in solidifying their own understanding of the concepts central to each activity or set of activities. Instructor observation of the students at work in this type of team environment provides multiple data points for more authentic and holistic views of what the students are actually learning as the learning is taking place.

In terms of measuring what students are actually learning, the following subsection provides a look at the learning outcomes, objectives, and assessment measures used in the course. This information is shared with the students on the first day of class. In addition, frequent reminders of outcomes and objectives are made throughout the semester.

A. Overview of Learning Outcomes and Assessment Measures

On the course syllabus students are provided with details regarding the learning outcomes and associated assessment measures. The learning outcomes for the course are highlighted in Table I.

Learning outcomes 1 - 8 are presented on the course syllabus in a very broad and generalized way. Table II builds on these learning outcomes by providing a specific set of learning objectives that are connected to each learning outcome. For clarity, the numbering scheme used in Table II corresponds to the numbering of the learning outcomes in Table I.

Table III highlights the assessment measures associated with the learning outcomes for the course. Again, this information is provided to the students through the course syllabus. Once again, the numbering scheme shown in Tables I and II is used.

Over and above the many opportunities to interactively engage with the course content through hands-on activities, the students also have a more unique opportunity to interact with the material. This opportunity comes in the form of preparing and presenting of a formal scientific research paper at a conference held on the last day of class. In the following section a presentation of the conference paper activity is shared along with its use as a direct measure of assessment.

TABLE I.
COURSE-SPECIFIC LEARNING OUTCOMES

Learning Outcome
1. Know basic physics terms.
2. Understand that units must be included when presenting or describing physical data and/or results.
3. Understand fundamental physical concepts and principles.
4. Understand appropriate problem solving techniques and methodologies.
5. Apply fundamental physical laws and principles.
6. Interpret and draw motion graphs.
7. Synthesize processes for obtaining a solution to a unique conceptual or numerical problem or situation.
8. Appreciate physics.

TABLE II.
OBJECTIVES ASSOCIATED WITH LEARNING OUTCOMES

Objectives Specific to Learning Outcome
1.1 Writing a definition of a specified term. 1.2 Providing the term that best fits a particular context. 1.3 Selecting the best term when given a definition. 1.4 Distinguishing between scalar and vector quantities. 1.5 Identifying the appropriate usage of a specified term.
2.1 Converting from the SI to the British system of units and vice versa, using learned techniques. 2.2 Distinguishing between units of various physical quantities. 2.3 Recognizing the appropriate unit for a given term. 2.4 Expressing proper units with each numerical result or data obtained through direct measurement.
3.1Selecting the appropriate law or relationship given a physical description of a situation. 3.2 Writing a description of a particular law or principle. 3.3 Recognizing an appropriate concept or principle for a given task. 3.4 Citing examples which exemplify fundamental laws and principles. 3.5 Relating fundamental laws and principles to given physical situations in the classroom and laboratory. 3.6 Writing a professional paper on a topic which involves the role physics has played (or is playing) in terms of the development of some aspect of our highly technological society and that can be linked to a topic(s) covered in the course.
4.1Outlining problem solving methodologies. 4.2 Recognizing appropriate uses of problem solving techniques. 4.3 Recognizing improper uses of problem solving techniques. 4.4 Explaining one's choice of problem solving methodologies. 4.5 Applying diverse modes of inquiry and critical reasoning to gather data and solve problems.
5.1 Distinguishing between appropriate and inappropriate applications of physical laws and principles. 5.2 Formulating solutions to problems based on appropriate laws and principles. 5.3 Solving problems that require the application of physical laws and principles. 5.4 Applying principles to new and different problem solving situations. 5.5 Demonstrating appropriate problem solving techniques.
6.1Drawing a graph of a particular motion of interest and determining its slope and y-intercept. 6.2 Describing the motion of an object in a given graphical representation. 6.3 Making interpretations based on a given graphical representation. 6.4 Selecting the graphical representation which best illustrates a given situation.
7.1 Using laws, principles, and concepts correctly and effectively. 7.2 Devising appropriate problem solving sequences leading to the solution of a unique problem. 7.3 Reorganizing given information into logical problem solving sequences. 7.4 Justifying the steps taken to solve a conceptual or quantitative problem. 7.5 Integrating various concepts learned into an effective problem solving strategy. 7.6 Demonstrating an understanding of the structures, patterns, principles, and values that affect the organization of societies and the relationship between the individual and society (with an emphasis on technology and its relationship to the individual and society). 7.7 Integrating problem solving and critical thinking skills using quantification, statistical analysis tools, and computer data manipulation.
8.1 Exploring real-world applications of the concepts, laws, and principles discussed. 8.2 Being encouraged to make connections between physics and one's individual major. 8.3 Making comparisons between various ways of looking at a given physical phenomenon. 8.4 Experiencing hands-on applications of physics, particularly through laboratory activities. 8.5 Exploring how scientists build models through which various physical phenomena can be analyzed and understood. 8.6 Analyzing how science works through the explicit examination of the historical development and current status of scientific methods, concepts, and principles. 8.7 Developing a respect for the finite resources of our planet, responsible use of technology and nuclear power, the limits of humane research, and the fragile wonders of the natural world.

TABLE III.
ASSESSMENT MEASURES

Learning Experiences and Assessment Measures used in PNM
1. You will have several opportunities to demonstrate your understanding of basic physics terms. These include: • Regular homework assignments. • Exams and quizzes that utilize a variety of question types (multiple choice, short answer, and numerical problem solving). • Frequent collaborative hands-on activities (called *Collabs)* that will require you to demonstrate your understanding of basic physics terms. • Preparation of professional conference paper.
2.Throughout **ALL** aspects of this course, whether in the classroom or during Collabs, the importance of units will be stressed.
3.You will have several opportunities to demonstrate your understanding of fundamental physics concepts and principles. These include: • Regular homework assignments. • Exams and quizzes that utilize a variety of question types (multiple choice, short answer, and numerical problem solving). • Collabs. • Preparation of professional conference paper.
4.Opportunities to demonstrate your understanding of appropriate problem solving techniques and methodologies include: • Regular homework assignments. • Exams and quizzes that utilize a variety of question types (multiple choice, short answer, and numerical problem solving). • Collabs. • Preparation of professional conference paper.
5.Opportunities to apply fundamental physical laws and principles include: • Regular homework assignments. • Exams and quizzes that utilize a variety of question types (multiple choice, short answer, and numerical problem solving). • Collabs. • Preparation of professional conference paper.
6.Some Collabs are designed to give you additional experience with graphical techniques. You may have opportunities to create graphs using our computer-based data acquisition system. In addition, you may also be required to produce and interpret some graphs that you have created by hand.
7.Opportunities to demonstrate your ability to synthesize processes used for both conceptual and numerical problem solving include: • Regular homework assignments. • Exams and quizzes that utilize a variety of question types (multiple choice, short answer, and numerical problem solving). • Collabs. • Preparation of professional conference paper.
8.Throughout the course you will have numerous opportunities to appreciate and value the physics you are learning. These opportunities include: • Collabs. • Preparation of professional conference paper. • Qualitative and quantitative problem solving.

V. ASSESSMENT OVERVIEW: THE CONFERENCE PAPER

A written conference paper serves as a direct measure for assessing student learning in the PNM course. The conference paper activity provides students an opportunity to experience all aspects associated with writing and presenting a scientific research paper to an audience of their peers. Furthermore, over the course of a given semester, students are exposed to all aspects of preparing a professional paper for publication. The paper writing experience includes:

- the submission of an abstract,
- the preparation of a first draft for instructor review,
- the preparation of a second draft for formal peer review, and
- the preparation of a revised, camera-ready copy for publication in the conference proceedings.

Students then present their final papers at a class conference held at the end of the semester.

Requiring students to write a written research paper is not, in and of itself, unique. In most instances where a research paper is required, the only thing that is assessed is the end product. This type of assessment does not provide students with the necessary feedback they need to improve upon their work. While this type of assessment might provide some insight into student learning, it is certainly lacking in many respects. Assessment of the end product provides little or no information about the actual learning process. Moreover, this type of assessment does not shed much light on how student learning was enhanced as a result of the writing experience because of the significant lack of a vital feedback loop. It is one thing to have students write a research paper in a class; and, it is quite another to assess student learning throughout the entire writing experience.

Within the PNM course assessment is done throughout all aspects of the writing process and is not based solely on the completed research paper. Each milestone of the paper-writing experience is designed to provide a "snapshot" to capture in real time what the students are actually learning as they are researching and writing their papers. To this end, a formal rubric is used as a record of student learning.

A. The Conference Paper Assessment Rubric

Unfortunately, instructors often give students a writing assignment for the sake of "giving them a writing assignment." In addition, the assessment of the students' writing is often subjective, and at best, superficial. While writing may be a useful tool to help students learn; using it as an assessment tool does pose some challenges. The use of a rubric can be an effective way to combat some of the challenges inherent in many writing assignments.

The rubric used to assess the formal PNM conference paper is illustrated in Fig. 3. The framework for the rubric centers on the major milestones of the paper writing process. A description of the significant assessment milestones of the paper writing process is provided in the following subsections.

CONFERENCE PAPER
SPRING 2013
EVALUATION FORM FOR:

____

	POINTS EARNED
1. Meeting to discuss abstract/paper topics week of 1/21/13. (10 points)	____
2. Abstract submitted on time (1/29/13). (10 points)	____
3. Meeting to discuss abstracts & first draft of paper week of 2/18/13. (5 points)	____
4. First draft of paper submitted on time (3/01/13). (10 points)	____
5. First draft reflects a draft of FULL paper (5 points/page; maximum 25 points)	____
6. Second draft submitted on time for peer review (3/26/13). (10 points)	____
7. Final (final) version submitted on time (4/16/13). (10 points)	____
8. Final version of conference paper	
a) Final paper substantially revised from 1st and 2nd submissions. (17 points)	____
b) Abstract revised to reflect final content of paper. (10 points)	____
c) Final paper 6 formatted pages in length. (7 points each page; maximum 42 points)	____
d) Final paper formatted following conference guidelines. (16 points)	____
e) Final paper made use of appropriate references.* (10 points)	____
*(No more than half of the references should be from web-based sources. Hewitt must be referenced.)	
TOTAL POINTS POSSIBLE: 175 **TOTAL POINTS EARNED:**	____

Figure 3. The conference paper assessment rubric.

B. Abstract Submission

At the very beginning of the semester, students are informed that they will have an opportunity to write a formal scientific research paper for publication in a class conference proceeding, and for presentation in a class conference to be held at the end of the semester. Specific details about the conference paper activity are provided to the students on the first day of class.

Students are allowed to choose a topic for their presentation that will permit them to demonstrate their understanding of a key topic area, or a set of topic areas, that will be discussed in class and were outlined in the previous section. Students are encouraged to choose a topic that might overlap with their major area of study, or something they are personally interested in and would like to know more about.

The students have approximately two weeks to select their topic and get instructor approval for it. In some cases, the instructor works with the students to help them narrow down and refine their topic choice. Once their topic has been approved, the students respond to a call for papers by submitting an abstract to the conference web site. From this point on, all aspects of the conference paper activity mirror those of an actual professional conference. The only difference is that no student papers are rejected at the abstract phase.

Approximately one week after the submission of abstracts, students are notified that their abstracts have been "accepted." Students are then "invited" to submit a first draft of their paper by a date set towards the midpoint of the semester. The submission of an abstract is the first milestone in the paper writing process. At this point, students begin the process of earning points towards their overall conference paper grade. Abstracts are not assessed for grammar and content at this point. Rather they are used as means for helping students put their research plans into clearer focus. In the next phase of the paper writing process, students carry out the necessary research and then prepare and submit a first draft of their papers for instructor review.

C. Preparation and Submission of First Draft for Instructor Review

One requirement during this phase of the process is that students meet with the instructor individually to talk about the focus of their papers. Quite often students tend to try and cover too much material when they begin their research. The instructor works with them to help them narrow and focus their research into a manageable amount. During this discussion, considerable attention is given to the type and nature of the resource material that the students have gathered.

Once the abstract submission and acceptance phase is completed, students spend approximately 6 – 7 weeks preparing the first draft of their full papers. Students must follow a formal set of guidelines as they prepare their first drafts, similar in nature to those used for the IGIP conference. The length requirement for the research papers is six formatted pages. This page length requirement is comparable to that of a standard 15 – 20 page, 12 point font, and double-spaced research paper. For the first draft, students are required to submit five fully-formatted pages. The final paper must be a minimum of six fully-formatted pages.

The first drafts of the papers are reviewed solely by the instructor. The instructor provides each student with individual reviews of their paper and does so in a professional format. At this stage of the conference paper activity, the instructor's goal is two-fold. The first is to provide students with concrete feedback so that they might revise their papers and prepare a 2nd draft; and the second is to serve as a model that students can refer to when they conduct their own individual peer reviews.

The feedback given to students focuses on both the quality as well as the content of the students' writing. Particular attention is paid to the specific physics content of the paper. Where discussion and descriptions might be sketchy, students are given suggestions and advice as to how they might enhance their writing through clarification and expansion of the physics content of their papers. Once students receive the instructor feedback, they receive a formal email from the instructor and are "invited" to submit a second draft of their full papers for peer review.

D. Preparation and Submission of a Second Draft for Peer Review

The next phase of the conference paper activity involves the preparation of a second draft that is submitted for peer review. Except for the fact that the papers are not blind reviewed, this phase of the activity mimics that of a professional peer review process. Students are given a set of guidelines for the peer review and are instructed to provide detailed comments on the paper that they've been assigned. Students spend approximately three weeks working on the second draft of their papers and are given one week to complete the peer review. Each student is assigned one paper to review.

In terms of assessment, the peer review activity is graded independently and is worth approximately 5% of the students' overall course grade. The independent assessment rubric used for the peer review is shown in Fig. 4. Once the peer review process has been completed students have about three weeks to complete and submit a final "camera ready" copy of their papers.

E. Preparation of Final "Camera Ready" Copy

Students are required to submit their camera ready copies approximately one week before the class conference which is held on the last day of class. One of the objectives of the conference paper activity is to provide students with a meaningful real-world experience. A second objective is to provide the instructor with a more authentic assessment measure that could be used in tandem with more traditional measures like exams and quizzes.

By moving through each milestone of the paper writing process, multiple opportunities present themselves for assessment of student learning. These opportunities were first noted in the assessment rubric for the conference paper (Fig.3). The rubric serves as an important marker for charting how the students' understanding of the subject matter covered within their papers has evolved over the course of the writing experience. The following sections provide an expanded view of the assessment process and showcases examples of actual student work.

VI. AUTHENTIC ASSESSMENT USING CONFERENCE PAPER WRITING EXPERIENCE

Authentic assessment involves the use of activities and tasks that involve replicas of those which are faced by adults in the professional world [35]. Furthermore, authentic assessment involves providing activities, problems, or questions of importance that require students to use their knowledge to fashion presentations of their work both effectively, and creatively. The creation and use of rubrics to evaluate student performance is common within the domain of authentic assessment.

As outlined in the previous section, each phase of the paper writing process was assessed. Students were earning points towards their overall conference paper grade at each milestone of the activity. Overall, the conference paper activity constituted approximately 30% of the students' course grade.

At the beginning of the term, students are informed that throughout each phase of the project they will be "banking" points towards their overall conference paper grade.

Conference Paper Peer Review
Spring 2013

Evaluation Rubric For: ______________________

Points Earned

1. **Critical Review of Paper. (30 points)** ______
   - Review was submitted on time
   - Written comments
     - i. were substantive
     - ii. were insightful and collegial
     - iii. addressed specific physics content
     - iv. addressed formatting issues appropriately as they related to paper formatting guidelines
     - v. addressed grammar and punctuation issues as appropriate

2. **Critical Response to Specific Questions. (20 points)** ______
   - Recommendation to author
     - i. on acceptance of paper was clear
     - ii. addressed the specific questions in a thorough and thoughtful manner using complete sentences
     - iii. provided substantive information in a collegial and professional tone of voice

TOTAL POINTS POSSIBLE: 50 **TOTAL POINTS EARNED:** ______

Figure 4. Assessment rubric for the peer review.

Armed with this information, students are empowered as they complete each phase of the activity. Each phase of the activity also provides the instructor with a way to more clearly chart each student's overall learning in a deeper and more robust way. For example, during the peer review process, the instructor gains valuable information about student understanding based on the nature of the comments and feedback the students provide to their classmates. Traditional pencil and paper exams often do not provide as complete a picture of the true level and depth of a students' understanding about a topic or set of topics.

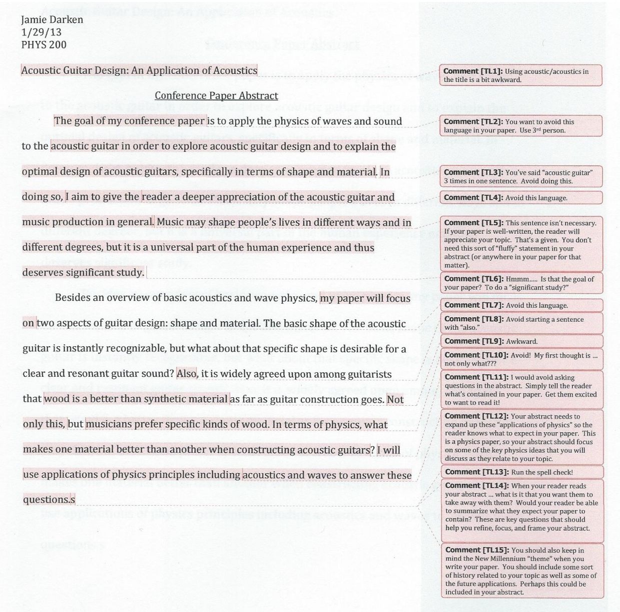
In the section that follows, some specific examples of how the assessment model described in the previous sections are utilized throughout the various phases of the conference paper activity. To provide a more authentic discussion, the actual course work of one student will be presented. This work exemplifies quality at all levels, and offers a realistic illustration of the assessment model utilized during the various phases of the conference paper activity.

VII. SPECIFIC EXAMPLES SHOWCASING THE ASSESSMENT PROCESS

The subsections that follow provide a picture of the assessment model employed throughout the various milestones of the paper submission process. Specific illustrations will utilize the work of student Jamie Darken (with his permission) from the spring 2013 PNM class. Jamie's paper focused on the physics involved in the design of an acoustic guitar.

A. Abstract Submission

The first phase of the paper process required students to submit an abstract for instructor review. A website was set up for students to submit their abstracts and subsequent paper drafts. Upon submission of their abstract, each student was given a paper ID number that they used for later submissions. Fig. 5 shows the abstract that Jamie submitted along with the instructor's constructive feedback.



Jamie Darken
1/29/13
PHYS 200

Acoustic Guitar Design: An Application of Acoustics

Conference Paper Abstract

The goal of my conference paper is to apply the physics of waves and sound to the acoustic guitar in order to explore acoustic guitar design and to explain the optimal design of acoustic guitars, specifically in terms of shape and material. In doing so, I aim to give the reader a deeper appreciation of the acoustic guitar and music production in general. Music may shape people's lives in different ways and in different degrees, but it is a universal part of the human experience and thus deserves significant study.

Besides an overview of basic acoustics and wave physics, my paper will focus on two aspects of guitar design: shape and material. The basic shape of the acoustic guitar is instantly recognizable, but what about that specific shape is desirable for a clear and resonant guitar sound? Also, it is widely agreed upon among guitarists that wood is a better than synthetic material as far as guitar construction goes. Not only this, but musicians prefer specific kinds of wood. In terms of physics, what makes one material better than another when constructing acoustic guitars? I will use applications of physics principles including acoustics and waves to answer these questions.

Comment [TL1]: Using acoustic/acoustics in the title is a bit awkward.
Comment [TL2]: You want to avoid this language in your paper. Use 3rd person.
Comment [TL3]: You've said "acoustic guitar" 3 times in one sentence. Avoid doing this.
Comment [TL4]: Avoid this language.
Comment [TL5]: This sentence isn't necessary. If your paper is well-written, the reader will appreciate your topic. That's a given. You don't need this sort of "fluffy" statement in your abstract (or anywhere in your paper for that matter).
Comment [TL6]: Hmmm..... Is that the goal of your paper? To do a "significant study?"
Comment [TL7]: Avoid this language.
Comment [TL8]: Avoid starting a sentence with "also."
Comment [TL9]: Awkward.
Comment [TL10]: Avoid! My first thought is ... not only what???
Comment [TL11]: I would avoid asking questions in the abstract. Simply tell the reader what's contained in your paper. Get them excited to want to read it!
Comment [TL12]: Your abstract needs to expand up these "applications of physics" so the reader knows what to expect in your paper. This is a physics paper, so your abstract should focus on some of the key physics ideas that you will discuss as they relate to your topic.
Comment [TL13]: Run the spell check!
Comment [TL14]: When your reader reads your abstract ... what is it that you want them to take away with them? Would your reader be able to summarize what they expect your paper to contain? These are key questions that should help you refine, focus, and frame your abstract.
Comment [TL15]: You should also keep in mind the New Millennium "theme" when you write your paper. You should include some sort of history related to your topic as well as some of the future applications. Perhaps this could be included in your abstract.

Figure 5. Abstract submission phase.

At the abstract phase students are just beginning to get started on their research and have just begun their library work. Further, the students are told that as they begin to formulate their research papers, the abstract should get modified and adjusted to better reflect the actual content of their papers. The instructor feedback is designed to help students focus on the physics content as well as to help them with things like professional language and structure.

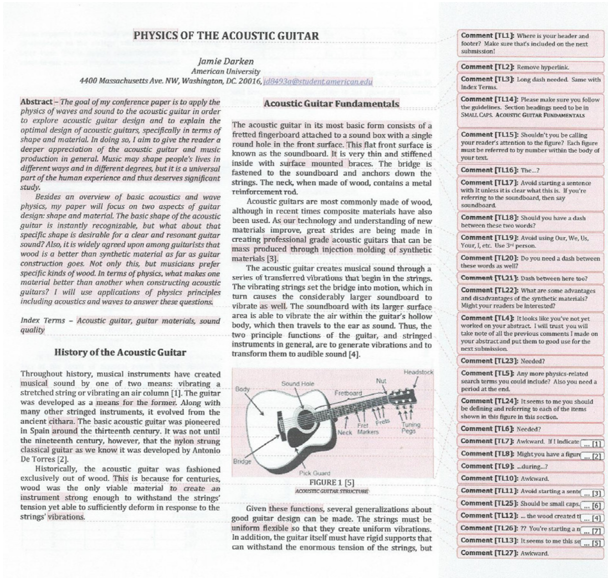
B. Submission of First Draft for Instructor Review

Following the submission of their abstracts, students have approximately one month to prepare the first drafts of their papers. Students were given a formal set of professional paper formatting guidelines that they were to follow as they prepared their drafts. The first drafts of the papers are reviewed by the instructor. Each student receives a detailed and comprehensive set of constructive comments from the instructor. Again, the focus is on the specific physics content along with the overall formatting of the paper. Fig. 6 shows a sample of the first page of Jamie's first draft.

While the instructor review process does take a good deal of time, it is time well spent. The estimated amount of time given to each paper at this phase of the process is approximately 2 – 3 hours. Because the class size is limited to 16 students, this is manageable. For larger class sizes, one could make use of TAs to assist with the reviews. Important to note is the fact that this is the only point in the writing process where the instructor provides this type of substantive feedback. It is the experience of the author that once students receive this feedback, they really understand the level of quality expected for the paper. In addition, students quickly learn the importance of using the language of physics in a deep and meaningful way as they present the research they've done on their respective topics.

C. Submission of Second Draft for Peer Review

Upon receipt of the instructor's feedback on their first drafts, students have approximately 3 weeks to complete a second draft of their paper. Students are then assigned



PHYSICS OF THE ACOUSTIC GUITAR

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American University
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Abstract – *The goal of my conference paper is to apply the physics of waves and sound to the acoustic guitar in order to explore acoustic guitar design and to explain the optimal design of acoustic guitars, specifically in terms of shape and material. In doing so, I aim to give the reader a deeper appreciation of the acoustic guitar and music production in general. Music may shape people's lives in different ways and in different degrees, but it is a universal part of the human experience and thus deserves significant study.*

Besides an overview of basic acoustics and wave physics, my paper will focus on two aspects of guitar design: shape and material. The basic shape of the acoustic guitar is instantly recognizable, but what about that specific shape is desirable for a clear and resonant guitar sound? Also, it is widely agreed upon among guitarists that wood is a better than synthetic material as far as guitar construction goes. Not only this, but musicians prefer specific kinds of wood. In terms of physics, what makes one material better than another when constructing acoustic guitars? I will use applications of physics principles including acoustics and waves to answer these questions.

Index Terms – Acoustic guitar, guitar materials, sound quality

History of the Acoustic Guitar

Throughout history, musical instruments have created musical sound by one of two means: vibrating a stretched string or vibrating an air column [1]. The guitar was developed as a means for the former. Along with many other stringed instruments, it evolved from the ancient cithara. The basic acoustic guitar was pioneered in Spain around the thirteenth century. It was not until the nineteenth century, however, that the nylon strung classical guitar as we know it was developed by Antonio De Torres [2].

Historically, the acoustic guitar was fashioned exclusively out of wood. This is because for centuries, wood was the only viable material to create an instrument strong enough to withstand the strings' tension yet able to sufficiently deform in response to the strings' vibrations.

Acoustic Guitar Fundamentals

The acoustic guitar in its most basic form consists of a fretted fingerboard attached to a sound box with a single round hole in the front surface. This flat front surface is known as the soundboard. It is very thin and stiffened inside with surface mounted braces. The bridge is fastened to the soundboard and anchors down the strings. The neck, when made of wood, contains a metal reinforcement rod.

Acoustic guitars are most commonly made of wood, although in recent times composite materials have also been used. As our technology and understanding of new materials improve, great strides are being made in creating professional grade acoustic guitars that can be mass produced through injection molding of synthetic materials [3].

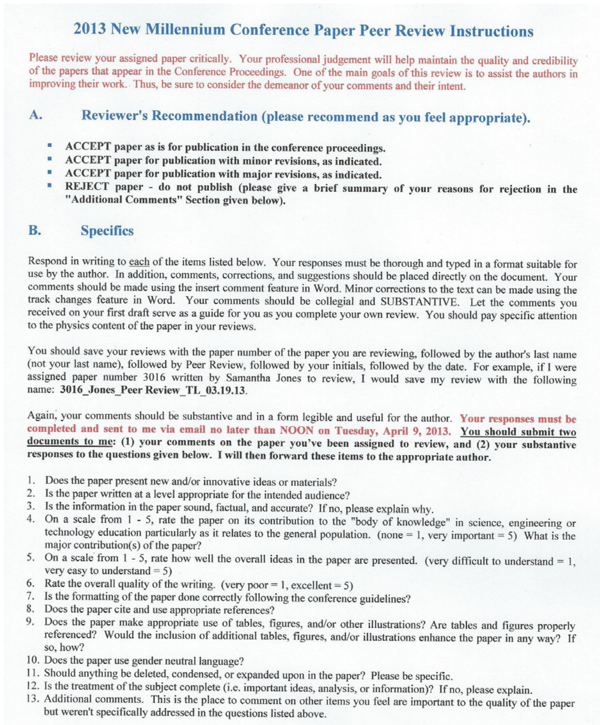
The acoustic guitar creates musical sound through a series of transferred vibrations that begin in the strings. The vibrating strings set the bridge into motion, which in turn causes the considerably larger soundboard to vibrate as well. The soundboard with its larger surface area is able to vibrate the air within the guitar's hollow body, which then travels to the ear as sound. Thus, the two principle functions of the guitar, and stringed instruments in general, are to generate vibrations and to transform them to audible sound [4].

FIGURE 1 [5]
ACOUSTIC GUITAR STRUCTURE

Given these functions, several generalizations about good guitar design can be made. The strings must be uniform flexible so that they create uniform vibrations. In addition, the guitar itself must have rigid supports that can withstand the enormous tension of the strings, but

Comment [TL1]: Where is your header and footer? Make sure that's included on the next submission!
Comment [TL2]: Remove hyperlink.
Comment [TL3]: Long dash needed. Same with Index Terms.
Comment [TL14]: Please make sure you follow the guidelines. Section headings need to be in SMALL CAPS. ACOUSTIC GUITAR FUNDAMENTALS
Comment [TL15]: Shouldn't you be calling your reader's attention to the figure? Each figure must be referred to by number within the body of your text.
Comment [TL16]: The...?
Comment [TL17]: Avoid starting a sentence with It unless it is clear what this is. If you're referring to the soundboard, then say soundboard.
Comment [TL18]: Should you have a dash between these two words?
Comment [TL19]: Avoid using Our, We, Us, Your, I, etc. Use 3rd person.
Comment [TL20]: Do you need a dash between these words as well?
Comment [TL21]: Dash between here too?
Comment [TL22]: What are some advantages and disadvantages of the synthetic materials? Might your readers be interested?
Comment [TL4]: It looks like you've not yet worked on your abstract. I will trust you will take note of all the previous comments I made on your abstract and put them to good use for the next submission.
Comment [TL23]: Needed?
Comment [TL5]: Any more physics-related search terms you could include? Also you need a period at the end.
Comment [TL24]: It seems to me you should be defining and referring to each of the items shown in this figure in this section.
Comment [TL6]: Needed?
Comment [TL7]: Awkward. If I indicate ... [1]
Comment [TL8]: Might you have a figure ... [2]
Comment [TL9]: ...during...?
Comment [TL10]: Awkward.
Comment [TL11]: Avoid starting a sente ... [3]
Comment [TL25]: Should be small caps. ... [6]
Comment [TL12]: ... the wood created t ... [4]
Comment [TL26]: ?? You're starting a n ... [7]
Comment [TL13]: It seems to me this se ... [5]
Comment [TL27]: Awkward.

Figure 6. First draft submission and instructor's feedback.



2013 New Millennium Conference Paper Peer Review Instructions

Please review your assigned paper critically. Your professional judgement will help maintain the quality and credibility of the papers that appear in the Conference Proceedings. One of the main goals of this review is to assist the authors in improving their work. Thus, be sure to consider the demeanor of your comments and their intent.

A. Reviewer's Recommendation (please recommend as you feel appropriate).

- **ACCEPT paper as is for publication in the conference proceedings.**
- **ACCEPT paper for publication with minor revisions, as indicated.**
- **ACCEPT paper for publication with major revisions, as indicated.**
- **REJECT paper - do not publish (please give a brief summary of your reasons for rejection in the "Additional Comments" Section given below).**

B. Specifics

Respond in writing to each of the items listed below. Your responses must be thorough and typed in a format suitable for use by the author. In addition, comments, corrections, and suggestions should be placed directly on the document. Your comments should be made using the insert comment feature in Word. Minor corrections to the text can be made using the track changes feature in Word. Your comments should be collegial and SUBSTANTIVE. Let the comments you received on your first draft serve as a guide for you as you complete your own review. You should pay specific attention to the physics content of the paper in your reviews.

You should save your reviews with the paper number of the paper you are reviewing, followed by the author's last name (not your last name), followed by Peer Review, followed by your initials, followed by the date. For example, if I were assigned paper number 3016 written by Samantha Jones to review, I would save my review with the following name: **3016_Jones_Peer Review_TL_03.19.13.**

Again, your comments should be substantive and in a form legible and useful for the author. **Your responses must be completed and sent to me via email no later than NOON on Tuesday, April 9, 2013. You should submit two documents to me: (1) your comments on the paper you've been assigned to review, and (2) your substantive responses to the questions given below. I will then forward these items to the appropriate author.**

1. Does the paper present new and/or innovative ideas or materials?
2. Is the paper written at a level appropriate for the intended audience?
3. Is the information in the paper sound, factual, and accurate? If no, please explain why.
4. On a scale from 1 - 5, rate the paper on its contribution to the "body of knowledge" in science, engineering or technology education particularly as it relates to the general population. (none = 1, very important = 5) What is the major contribution(s) of the paper?
5. On a scale from 1 - 5, rate how well the overall ideas in the paper are presented. (very difficult to understand = 1, very easy to understand = 5)
6. Rate the overall quality of the writing. (very poor = 1, excellent = 5)
7. Is the formatting of the paper done correctly following the conference guidelines?
8. Does the paper cite and use appropriate references?
9. Does the paper make appropriate use of tables, figures, and/or other illustrations? Are tables and figures properly referenced? Would the inclusion of additional tables, figures, and/or illustrations enhance the paper in any way? If so, how?
10. Does the paper use gender neutral language?
11. Should anything be deleted, condensed, or expanded upon in the paper? Please be specific.
12. Is the treatment of the subject complete (i.e. important ideas, analysis, or information)? If no, please explain.
13. Additional comments. This is the place to comment on other items you feel are important to the quality of the paper but weren't specifically addressed in the questions listed above.

Figure 7. The peer review guidelines.

one paper that they will review as part of the peer review phase of the paper writing process. To that end students are given a set of peer review guidelines. These guidelines are illustrated in Fig. 7.

Using the instructor feedback they received on their first drafts as a model, students were instructed to provide substantive written feedback on the paper they were assigned to review using the "track changes" and "comment" features available in Microsoft Word. In addition, students were also required to provide a detailed response to a set of questions that were part of the peer review guidelines.

Fig. 8 provides an illustration of the review that Jamie conducted on classmate Juan Heilbron's paper (presented with his permission). Juan's paper was on the physics of electric guitars, so the pairing of these students for the peer review was done intentionally. Given that Jamie and Juan were writing on similar topics, the quality of the feedback they could provide one another was enhanced. In most instances, students were assigned papers for peer review that in some way overlapped with the topic of their own research.

While a number of comments on the page represented in Fig. 8 are stylistic in nature, the overall quality of the physics-specific comments throughout the entire paper was excellent. For example, specific comments Jamie provided Juan regarding the physics content of his paper include the following:

- “The pickups don’t register the sound specifically. They register the vibrations of the strings. It’s a subtle but key difference.”
- “You mean they are permanent magnets or that their magnetic domains are easily aligned?”
- “You’re leaving out a crucial part of Faraday’s Law: the wire.”
- “I think your discussion of physics can be enhanced here. How exactly do all the variables related and what does each one do to the frequency?”
- “Tension is still a factor, it’s just constant across the strings.”

Comments such as these assist the instructor in assessing the level of physics understanding of the student conducting the review. This type of assessment is often much more revealing than any kind of traditional assessment measure could provide. In addition, sometimes the students’ comments pertain to material the students learned in their first-level physics. Comments of this type provide an added bonus in that the instructor has the opportunity to see how students are making connections between the first- and second-level physics courses. The bonus for the student comes in discovering how connected the material covered in the two courses really is.

The peer review assessment rubric originally shown in Fig. 4 is provided to the students as they begin their peer reviews. Once the peer reviews have been completed, the students receive a copy of the rubric along with their scores for each of its components.

D. Submission of Final “Camera-Ready” Copies

Fig. 9 is an illustration of Jamie’s final paper submission. Through the final paper Jamie demonstrated keen attention to formatting details. In addition, his discussion of the physics content of his paper was strong and appropriate for an audience of his peers.

Near the beginning of the paper writing process, students were shown the conference paper assessment rubric (Fig. 3). Hence, they were advised in advance as to how their work would be assessed. The students knew understood that they were “banking” points towards their overall paper grade through each part of the process. Students earned points towards their overall paper grade as they completed each required part of the paper. The final copy of their papers were worth a substantive amount of points as it is here that they are demonstrating that they’ve utilized the feedback they’d been given. In addition, each phase of the process was designed to empower students to make their final papers the best that they could be.

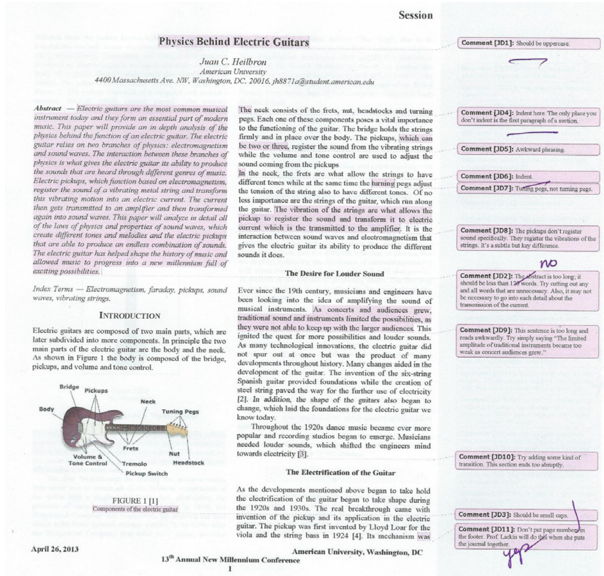


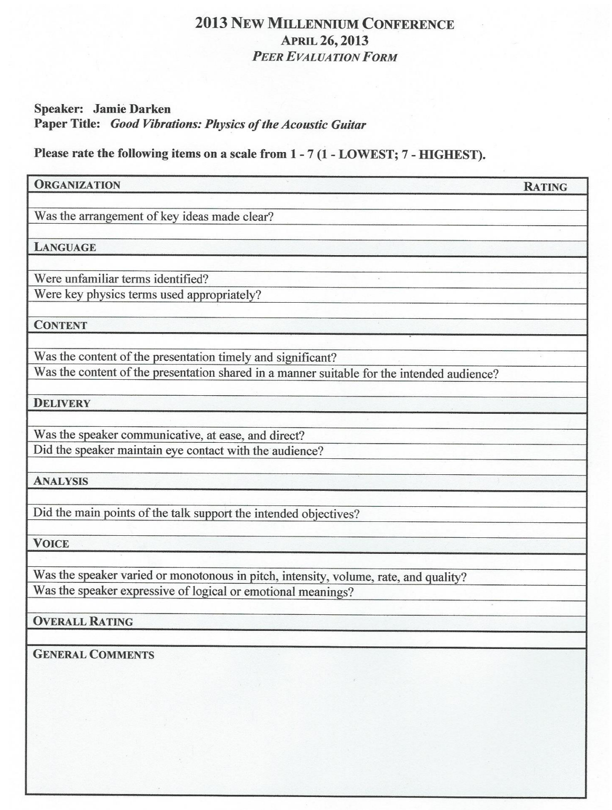
Figure 8. Sample student peer review.

Figure 9. Final camera-ready submission.

E. The Class Conference

On the last day of class a formal conference was held so that students could present their papers. All student papers were published in a bound conference proceedings and distributed on the day of the conference. Two days prior to the actual conference, students met with the instructor in order to practice their formal presentations. Students were required to prepare a PowerPoint for use during their presentations. These practice sessions provided the instructor with an additional opportunity to provide students with constructive feedback. In addition, these sessions provided another data point for issuing a grade for the conference presentation.

During the conference, students conducted a formal peer review of the presentations made by their peers. A copy of the rubric used by the students for these reviews is shown in Fig. 10.



2013 NEW MILLENNIUM CONFERENCE
APRIL 26, 2013
PEER EVALUATION FORM

Speaker: **Jamie Darken**
Paper Title: ***Good Vibrations: Physics of the Acoustic Guitar***

Please rate the following items on a scale from 1 - 7 (1 - LOWEST; 7 - HIGHEST).

ORGANIZATION	RATING
Was the arrangement of key ideas made clear?	
LANGUAGE	
Were unfamiliar terms identified?	
Were key physics terms used appropriately?	
CONTENT	
Was the content of the presentation timely and significant?	
Was the content of the presentation shared in a manner suitable for the intended audience?	
DELIVERY	
Was the speaker communicative, at ease, and direct?	
Did the speaker maintain eye contact with the audience?	
ANALYSIS	
Did the main points of the talk support the intended objectives?	
VOICE	
Was the speaker varied or monotonous in pitch, intensity, volume, rate, and quality?	
Was the speaker expressive of logical or emotional meanings?	
OVERALL RATING	
GENERAL COMMENTS	

Figure 10. The presentation peer review rubric.

Immediately after the conference, students were given the feedback provided them by each of their peers. The instructor never looked at this feedback nor did it in any way affect their conference presentation grade. The intent of the feedback was merely to provide constructive comments to each student author as a means for reflection and self-improvement.

The entire conference was also video-taped. There were many student and faculty guests at the conference. In addition, some parents were in the audience. A few days after the conference, students were given copies of the conference DVD. Students could then view the conference and their individual presentations at their leisure, again for the purposes of reflection and self-improvement.

VIII. SUMMARY

One of the goals of having students write a scientific research paper and then present it at a class conference was to give them an opportunity to conduct research on topics that they deemed interesting; while simultaneously allowing them to uncover, on their own, links between physics and their major or other interest area. Oftentimes students taking a traditional physics course have difficulty relating the topics studied to real-world situations and applications. The research paper experience can perhaps give a more authentic voice to the physics the students are learning about in the classroom.

An additional goal of the paper writing activity was to provide students with a genuine experience in which they could demonstrate to the instructor that they had a solid understanding of the physics content covered during the term. The conference paper activity clearly provided the instructor with more meaningful and robust information about student learning. Because each milestone of the activity had an assessment component, the instructor was often able to help students to correct a flaw in their thinking while the learning was actually taking place. More traditional assessment measures like exams and quizzes are typically given "post mortem" and therefore do not have a built-in mechanism to correct flawed thinking like authentic, formative measures do. The conference paper activity provided students an opportunity to demonstrate, at a deeper level, their understanding of physics while simultaneously providing them with a learning experience that would serve them well, long after the semester comes to an end.

Having students write a formal research paper and then present it during a formal class conference also provided the opportunity for improvement of both written and oral communication skills. Having strong communication skills is of critical importance as students begin to prepare their resumes and start applying for internships, summer co-op experiences, or for professional positions after graduation. College faculty are routinely asked to prepare letters of recommendation for students that they've had in class. Without exception, every recommendation comes with instructions to comment on students' written and oral communication skills. Having had students go through the conference paper activity described here provides them with an invaluable resource. Students frequently cite the PNM conference on their resumes and provide a copy of their paper to future employers as evidence of their writing skills. In fact, a student who took the spring 2013 PNM course recently expressed that while submitting applications for professional employment after graduation, he's been using his conference paper for several of his job applications and it has garnered a great deal of attention [Andrew Stern, personal communication, Nov. 20, 2013]!

From both the instructor and student perspective the conference paper activity is a "win-win." The instructor gets a chance to add an alternative and more authentic assessment tool to the course design; and, the students have a chance to produce a scientific research paper that has the potential to do much more than simply help them learn physics.

ACKNOWLEDGMENT

The author wishes to acknowledge all of the students in her past PNM classes. A special thank you goes to the students in the spring 2013 class. You were an amazing group of students to work with! She'd also like to thank her outstanding TAs (Kaitlyn Martell, Ben Chesneau, and Alex Marshall) who provided invaluable assistance during the second round of paper reviews. A special thank you also goes to Jamie Darken and Juan Heilbron for granting me permission to cite examples from their original class work.

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