Session 3280

Writing as an Assessment and Learning Tool

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Abstract *- Writing has long been established as a valuable strategy for learning within many disciplines. A unique writing strategy, called a "folder activity," has been developed for use with introductory physics students at American University. The folder activity has proven to be a successful and effective learning tool for students for many reasons. For example, students are often able to uncover their misconceptions through this writing activity very early in the course. This early uncovering challenges students to confront and deal with their misconceptions. Unfortunately, many learning strategies do not give students an opportunity for early detection of potential problems in their understanding. The folder activities, however, provide students with a non-threatening vehicle through which they can deal with their misconceptions, before they take a major quiz or exam. This paper will focus on the utility and function of the folder activity as a learning tool. In addition, the specific elements of the folder activity will be described and samples of students' writings will be shared. Finally, role of the folder activity as an assessment tool will be outlined.*

Introduction

Writing has long been established to be an effective means of expressing one's ideas, thoughts, and understanding. In recent years, attention has been placed on various writing-to-learn strategies in mathematics and science (Connolly & Vilardi, 1989; Countryman, 1992; Hein, 1998). Emphasis here is placed on using writing as a vehicle for students to develop their critical thinking skills and ultimately learn more. In addition, Mullin (1989) contends that writing "... is an especially valuable tool for encouraging heuristic thinking and learning" (p. 347).

Science classes, in general, are seen by many students to be threatening and intimidating places to attempt to learn. Tobias (1990) has been critical of introductory college science courses and has argued that typical classrooms are "... competitive, selective, intimidating, and designed to winnow out all but the 'top tier' ... there is little attempt to create a sense of 'community' among average students of science" (p. 9). Hence, a traditional science classroom may present potential barriers that could inhibit learning for some students. I contend that writing can provide a non-threatening vehicle through which students can achieve deeper, more meaningful learning of the concepts presented. In addition, writing can provide an excellent mechanism to allow students to confront and deal with their often deep-seated misconceptions. Tobias (1989, p. 50) contends that writing can serve as a means to help students relieve their anxiety and help them unlearn models and techniques that are no longer useful to them. In addition, Tobias suggests that eventually students would be able to approach new concepts and problems with confidence.

This paper describes a unique writing activity (simply called a "folder activity") I have developed for use by students in my introductory physics class for non-science majors at

American University. The pedagogical base for the folder activity described in this paper comes, in part, from various writing-to-learn strategies. In addition, the folder activity was further developed and refined based on Tobias' argument that science classes can be seen by many students as being cold, threatening, and intimidating. Hence, folder activities give students an opportunity to share their understanding of a particular topic or concept in a non-threatening, yet effective way.

The Introductory Physics Course at American University

The introductory course for non-science majors at American University in Washington, D.C. is a one-semester, algebra-based course and is entitled *Physics for the Modern World*. Topics covered in the course typically include Kinematics, Newton's Laws, Conservation of Momentum and Energy, Rotational Motion, Fluid Mechanics, Waves, and Sound. Although traditional in its content, the course is not taught in a "traditional lecture format." I have developed numerous teaching strategies that I use in the course which center around accommodation of students' diverse learning styles (Hein, 1995). In addition, the course includes both strong conceptual and problem solving components.

Physics for the Modern World is a 3-credit course and consists of a lecture and a laboratory component. Students meet twice a week for class sessions which are 75 minutes long. On alternate weeks students meet for a two-hour laboratory. Approximately 130 students, with 65 students in each of two sections, enroll in the course each semester.

Many students who enroll in *Physics for the Modern World* are liberal arts majors. A typical class consists of a mixture of students from the College of Arts and Sciences, the School of Public Affairs, the School of International Service, and the Kogod College of Business Administration. Students enroll in *Physics for the Modern World* to satisfy a portion of the Natural Science requirement for graduation at American University. Students may choose to satisfy this requirement with either a general Physics, Chemistry, Biology, or Psychology course.

Due to the wide range of majors in the course, one could assume that the diversity of students enrolled in *Physics for the Modern World* closely parallels the diversity of students enrolled at American University. The 1995 - 96 American University catalog describes its student population as being "... cosmopolitan and multicultural ..." ("The American," p. 61). The spring 1998 classes of *Physics for the Modern World* include students from 25 states and 22 countries.

The Folder Activity Described

As part of their homework assignments, students in the *Physics for the Modern World* class are required to keep a two-pocket folder. The folder activity provides students an opportunity to display their understanding of a topic or concept through the use of writing. Students are required to make one entry in their folders approximately every other week. Thus students receive 5 - 10 folder assignments each semester. Upon collection of the students' folders, I set aside a block of time to read them and provide students with written feedback. This written feedback is absolutely essential. Numerous studies have pointed out the importance and value of prompt and thoughtful feedback to the students (Brown & Knight; 1994; Gastel, 1991; Harmelink, 1998; Wiggins, 1997). Once the folders are returned, students are encouraged to reflect on my comments and then work to confront any potential difficulties they are having with a particular concept. Hence, the folder activities have proven to be a highly effective tool in helping students uncover and then wrestle with their misconceptions while the learning is taking place.

The nature of the folder assignments vary, depending on specific objectives and goals for a particular topic or content area. One strategy that has proven to be quite effective is to ask students to "put on their teacher hats" and describe a particular phenomena to a friend or classmate. For example, for some folder assignments I have asked students to explain a problem or a concept that was highlighted or discussed during a class session to a classmate who may have missed class (for a legitimate reason, of course!). Thus, students essentially have the "answer" to the problem in their hands when they write up this type of folder assignment. What the folder assignment encourages students to do is to think critically about the "how" and the "why" of a particular solution. Furthermore, the students must articulate in writing their conceptual reasoning behind a problem in their own words.

An additional example of the kinds of activities students are asked to respond to in their folders involves the creation of sample test questions. I sometimes ask students to write a multiple choice or other form of exam question that would illustrate a student's understanding of a particular physics concept. In addition to writing a question, students must explain their choice of responses (for a multiple choice question) including the reasoning behind both the correct response as well as the incorrect options. After reading the students' questions, I will typically type up and hand out a page of some of the questions written by the students. The students seem to really appreciate this and many find them useful in preparing for exams and quizzes.

Once students complete their folder assignments I ask them to read them over to see if they have addressed everything asked for in the assignment. I encourage the students to ask themselves whether their written responses satisfy their own need to know and to understand the topic. In addition, I sometimes require students to have someone else, who is preferably unfamiliar with physics, read their responses and comment on them BEFORE they hand them in to me.

The folder activities are not intended to be long assignments. I do not specify a length requirement; rather, I tell the students to use their judgment. Typical student responses range in length from 1/2 - 3 pages. I do encourage students to use a word processor and run the spelling and grammar checks before submitting their folders.

I also tell the students that the folder activity is not about their putting down "what they think the professor wants to hear." I encourage students to share with me their understanding of the particular topic or concept in their own words. Thus, students are not pressured to bog their writing down with scientific jargon. This gives me a much clearer window into the students' thoughts and to their level of understanding. Students understand that the folder assignments are designed to help them uncover conceptual difficulties they may be having before they take a major quiz or exam.

I encourage students to be as creative as they would like to be with their folder assignments. Furthermore, I encourage the use of pictures, photographs, drawings, cartoons, stories, and newspaper and magazine clippings. Students' seem to appreciate having the opportunity to express themselves in this manner. I have received a large number of very creative entries from my students. For example, I have had students write up fictional short stories and plays in response to my questions. Others include personal photographs of themselves or someone they know "doing physics!" Still others will share personal experiences they have had that involved some physics. In addition, students frequently add "extra" items to their folders such as timely news-type items where physics is involved. The bulletin board outside my office is filled with physics-related cartoons students have slipped into their folders!

Samples of Students' Writing

Over the course of a semester, students are asked to make several entries in their folders. For the sake of space, a single example will be illustrated here. During the fall 1997 semester, students were given the following assignment in their third folder activity:

In Chapter 4 of your text (Hewitt, 1998) you were assigned a question regarding a Mack truck and a Honda Civic. The question specifically asked: "If a Mack truck and a Honda Civic have a head-on collision, upon which vehicle is the impact force greater? Which vehicle experiences the greater acceleration? Explain your answers." For this question you primarily made use of Newton's Laws of motion in your response. Now what I would like you to do is take the concepts from Chapter 4 on Newton's Laws and integrate them with the concepts we've discussed in Chapter 5 regarding momentum and impulse and respond to the following question: "If a Mack truck and a Honda Civic have a head-on collision, which vehicle will experience the greater force of impact? The greater impulse? The greater change in momentum? The greater acceleration?" Please respond to these questions as if you were talking to someone who is unfamiliar with these concepts (i.e. put on your "teacher hat"). Try and respond to them in a manner that you would be satisfied with if you were the recipient of your own explanation. Feel free to draw diagrams, tell a story, etc. In other words, do what you feel you need to do to thoroughly explain these questions.

I have chosen to include two unedited examples of student responses to this question which I will refer to as Student A and Student B. Student A's response indicates a fairly good understanding of the concepts. Student B's response, on the other hand, clearly indicates there are some conceptual difficulties that need to be addressed.

Student A: "If a Mack truck and a Honda Civic had a head-on collision, there would most likely be considerable damage to both. However, how severely each would be impacted by the collision depends on the physics involved. Although the truck is much bigger than the car, the force of impact on both is the same according to Newton's 3rd Law of action-reaction pairs. The law states that whenever a force is exerted on an object, that object exerts an equal and opposite force on the first object. Therefore, the truck exerts a force on the car equal and opposite to the force the car exerts on the truck. In determining the force of impact, the masses of the truck and car do not affect the force. The acceleration of the two *does* depend on their masses, however. If a large mass, such as the truck's, is acted upon by a given force, the resulting acceleration will be small in comparison to the acceleration of a small mass, acted upon by the same force. Thus, the car, having the smaller mass, would experience a greater acceleration. This is shown by:

Truck: $\frac{F}{\mathrm{M}} = a$ Car: $\frac{F}{m} = \mathrm{A}$

(Note: Here the student is using the size of the letters to indicate the relative magnitude of the representative quantity.) The masses of the vehicles are also important in determining their respective momentums. Momentum is a product of the mass of an object and its velocity; if the two vehicles are traveling at the same speed, the truck would have more momentum because of its greater mass. If there is a change in the velocity of one of the vehicles, however, then a change in momentum results. The change in momentum is called an *impulse*, which is a product of the force and time. Because the forces are equal due to Newton's 3rd Law, and we can assume the time factor is the same, the respective momentums of the truck and car would change the same amount because the factors are the same. Therefore, neither experiences a greater impulse. Because neither vehicle experience a greater impulse, the total momentum before the collision is equal to the total momentum after the collision; momentum is conserved. Thus, again, neither vehicle experiences a greater change in momentum. It is important to distinguish between momentum and speed; the change in momentum is the same for both, but the change in speed would vary. Because the truck's mass is greater, its reduction of speed would be less than that of the car, which would experience a greater reduction of speed due to its smaller mass. We see that the car would probably experience more damage due to its greater acceleration and greater reduction in speed. It is interesting to note, however, that the forces acting upon both the car and the truck are equal, and that neither would experience a greater change in momentum, i.e. a greater impulse.

<u>Student B</u>: "At the Accident Scene: If a Mack truck and a Honda Civic collide, the greater force of impact is equal upon both vehicles. But the masses of the vehicles are different. Since the Mack truck has a much greater mass, its acceleration will be less and since the Civic has a smaller mass, its acceleration will be greater upon impact. The impulse will be greater in the truck because while forces are equal, it will take the truck a longer time to stop than it will for the civic. In another way, the change in momentum is greater in the truck, so the impulse is greater. The reason that the truck has a greater change in momentum is because it had greater momentum to begin with due to the truck's greater mass, assuming both vehicles were going at the same speed -- equal velocities. The greater acceleration is on the truck as well because of its greater momentum. [Force × time interval = change in (mass × velocity)]"

Clearly there are several conceptual difficulties with Student B's response. One of the difficulties the student has is in understanding that the time interval called for in the impulse relationship represents the collision time, which is the same for each vehicle. The student confuses the collision time with the time to stop after the collision. In reading the students' folders it became clear to me that several students harbored this same misconception. I was then able to not only provide individual written feedback to the students in their folders, but I was also able to re-address this issue in class since several students shared the same conceptual difficulty. Had I not given the students the opportunity to express their understanding through this folder activity, I would not have uncovered this difficulty until after the students' had taken a quiz or exam (which is obviously much too late for the students).

Assessment of Students' Writing

In my course syllabus, I provide students with a description of the folder activities. As the folder activities are somewhat unique, especially in a physics course, I spend some class time discussing my expectations. In terms of assessing the quality of the folder activities, I provide students with a rubric (which is similar to a checklist) outlining my expectations. The key element of the rubric involves the thoroughness with which they present their responses. For example, a simple opinion statement that is unsupported by a physics principle or relationship would be considered a weak entry. A strong entry would be complete, well documented, and illustrated in terms of the physics involved.

My assessment strategy is rather unique. I do not penalize students for incorrect use of physics. That's right - no points are deducted if they get the physics wrong. Not penalizing students for incorrect use of physics helps to make the folder assignments non-threatening. In fact, I do not even put a numerical grade on their folder assignments until the end of the semester! Thus, students are forced to look at my written comments, rather than a numerical score when I return their folders to them. What I intend for the students to do is to think very deeply about my comments and then do whatever they need to do to correct the flaws in their thinking. I am trying to get students away from just looking at their numerical scores and then filing the activity away, oftentimes never to be looked at again. Thus, if a student makes a sincere attempt to back up their statements with some physics, and they follow all the directions specified in the assignment, they will receive full marks for that activity.

In addition to not penalizing students for incorrect use of physics, I do not grade students' folder assignments for grammar and spelling. If a word is misspelled I will indicate that to the student, but I do not mark them down for it. Surprisingly, the papers that my students turn in to me are remarkably well written. I feel that because I read the students' papers so thoroughly, this actually provides incentive for them to do a good job. Thus, I feel the feedback that I provide to the students' has an added benefit as it seems to encourage students to put some serious thought and energy into what they turn in.

Approximately one-third of my students each semester are international students. I have not found that the fact that English is not the first language of many of my students to present any serious problems. Moreover, I do not feel that language is a barrier to the students' learning of physics. In fact, the folder activities have an added benefit for all of the students, whether English is their first language or not; and that is their communication skills are enhanced.

Conclusions

An essential part of the folder activity is the written feedback I provide to my students. I have found that the instructor/student relationship is fostered and enhanced. My students have indicated to me that they appreciate my concern regarding their learning and understanding of the physics concepts. I feel that because I take the time to provide my students with written feedback, they take the activity very seriously and most turn in rather high quality work. Although not required, I have had several students who take the time to respond to the feedback that I have provided them with. Other students ask to resubmit their responses, if their thinking was particularly flawed where the physics is concerned. It is important to keep in mind that these students are not penalized for incorrect use of physics, so the fact that some students want to resubmit their responses is commendable. It appears that this writing activity serves to motivate some students to go beyond what is required for the sake of learning some good physics.

The folder activities also provide me with an additional assessment tool beyond such things as typical paper and pencil tests. However, there is one shortcoming to the folder activities, and that is they take considerable time to read and respond to, especially for instructors dealing with large numbers of students as I am. One strategy that I have used to handle working with such large numbers of students is that I sometimes stagger the assignments so that not all students are submitting their folders at the same time. Since I teach two large sections of introductory physics I often collect folders from one section at a time. I have found it particularly enlightening to ask students in one section to respond to a question on a particular topic *before* we have discussed it in class and the other section to respond to the same question *after* we have discussed it in class.

The folder activities have proven to be an effective way of helping students make deeper connections to the physics content under study. The act of explaining one's thoughts through writing can lead to the sharpening of critical thinking skills. In addition, students are encouraged to make linkages between physics and their lives through the folder activities. It is my belief that when students can make a connection between physics and their own lives, long-term learning and retention of material is encouraged and enhanced.

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