Portfolios

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WHY USE PORTFOLIOS?
Portfolio assessment strategies provide a structure for long-duration, in depth assignments. The use of portfolios transfers much of the responsibility of demonstrating mastery of concepts from the professor to the student.

WHAT ARE PORTFOLIOS?
Student portfolios are a collection of evidence, prepared by the student and evaluated by the faculty member, to demonstrate mastery, comprehension, application, and synthesis of a given set of concepts. To create a high quality portfolio, students must organize, synthesize, and clearly describe their achievements and effectively communicate what they have learned.

WHAT IS INVOLVED?
Instructor Preparation Time: Minimal, after the course learning objectives have been clearly identified. Can be high if multiple graders are to be trained (e.g., graduate teaching assistants) when used in large classes.
Preparing Your Students: Clear expectations must be provided to students at the beginning of the course.
Class Time: None.
Disciplines: Appropriate for all.
Class Size: Most applicable in small classes (n < 30); possible in large classes with pre-existing infrastructure and less “open ended” character of evidence allowed.
Special Classroom/Technical Requirements: None.
Individual or Group Involvement: Individual.
Analyzing Results: Intense and requires a scoring rubric.
Other Things to Consider: Materials are presented in the natural language of the student and will vary widely within one class.

Contents

Description

Student portfolios are a collection of evidence, prepared by the student and evaluated by the faculty member, to demonstrate mastery, comprehension, application, and synthesis of a given set of concepts. Accordingly, portfolio assessment strategies substantially increase the rigor of an introductory science or mathematics course. For example, in a physics course, this might include quantitative analysis of a video showing motion. In a geology course, this might include an analysis of the impact of agriculture on the community's water quality using locally acquired data. Students must organize, synthesize, and clearly describe their achievements and effectively communicate what they have learned. The evidence can be presented in a three-ring binder, as a multimedia tour, or as a series of short papers.

A unique aspect of a successful portfolio is that it also contains explicit statements of *self-reflection*. Statements accompanying each item describe how the student went about mastering the material, why the presented piece of evidence demonstrates mastery, and why mastery of such material is relevant to contexts outside the classroom. Self-reflections make it clear to the reader the processes of integration that have occurred during the learning process. Often, this is achieved with an introductory letter to the reader or as a summary at the end of each section. Such reflections insure that the student has personally recognized the relevance and level of achievement acquired during creation and presentation of the portfolio. It is this self-reflection that makes a portfolio much more valuable than a folder of student-selected work.

Assessment Purposes

The overall goal of the preparation of a portfolio is for the learner to demonstrate and provide evidence that he or she has mastered a given set of learning objectives. More than just thick folders containing student work, portfolios are typically personalized, long-term representations of a student's own efforts and achievements. Whereas multiple-choice tests are designed to determine what the student <u>doesn't</u> know, portfolio assessments emphasize what the student <u>does</u> know.

Limitations

Portfolio assessments provide students and faculty with a direct view of how students organize knowledge into overarching concepts. As such, portfolios are inappropriate for measuring students' levels of factual knowledge (i.e., recall knowledge) or for drill-and-skill activities and accordingly should be used in concert with more conventional forms of assessment. Similarly, student work completed beyond the context of the classroom is occasionally subject to issues of academic dishonesty.

Teaching Goals

- Develop ability to communicate scientific conceptions accurately
- Develop ability to write effectively using graphics as support
- Develop ability to relate principle concepts to real-world applications
- Develop ability to cite sources and references appropriately
- Develop ability to synthesize and integrate information and ideas
- Develop ability to be reflective and effectively conduct self-assessment
- Develop ability to think creatively and critically

Suggestions for Use

Portfolios are most appropriate when students need to integrate a number of complex ideas, procedures, and relationships. Portfolios can more much of the responsibility of assessment from the instructor to the student if the learner is instructed to demonstrate and provide evidence that he or she has mastered a given set of learning objectives. The most useful portfolios are composed of student solutions to multifaceted tasks. Such tasks are typically complex, somewhat undefined, engaging problems that require students to apply, synthesize, and evaluate various problem-solving approaches.

Step-by-Step Instructions

- Carefully construct and distribute 12-25 overarching learning objectives for the course.
- Decide if a portfolio supports student learning and assessment for these objectives.
- Determine if the portfolio is primarily a learning activity or an assessment tool.
- Inform students of your expectations that students have the opportunity to clearly demonstrate to the professor that course learning objectives have been attained.
- Require that each piece of evidence must be clearly labeled as to which objective the evidence pertains.
- Require that each piece of evidence must be accompanied by a written paragraph of rationale and a separate written paragraph of self-reflection.
- Emphasize to students that it is their responsibility to clearly demonstrate mastery of the learning objectives for this course.
- Score each item of evidence in the portfolio according to a scheme that has been distributed to the students when the portfolios are initially assigned.

Figure 1: Illustrative Course Learning Objectives

List of Course Learning Objectives for Introductory Environmental Geology

1. The size of the human population, and the causes for change in its size in various areas of the world.
2. The source, use, pollution and cleanup of the worlds water resources.
3. The origin and evolution of soils, and the way soils are affected by agriculture.
4. Current and alternative sources of food.
5. The origin, advantages and disadvantages of current sources of energy.
6. The origin, operation and potential for alternative sources of energy.
7. The causes of extinction and the processes which control the rate of extinction.
8. Factors which control the use of land by people.
9. The geologic processes which cause earthquakes, and the potential for predicting and preventing such events.
10. The origin, extraction and importance of ores.
11. The composition, management and recycle potential for solid & hazardous waste material.
12. The origin, evolution and productivity of coastal areas.
13. The impact of human activities on coastal areas.
14. The origin, effect and remediation of atmospheric pollution.
15. How humans affect the earth's environment.

List of Course Learning Objectives for First Semester Algebra-based College Physics

1. Understand the nature of scientific knowledge and the various disciplines of science.
2. Appreciate the historical and practical uses of units and measures.
3. Convert numerical quantities from one system of units to another and within a given system.
4. Describe the various concepts and units used to describe motion.
5. Solve one-dimensional problems related to the acceleration of objects due to gravity.
6. Diagram and describe quantitatively the motion of a projectile.
7. Appropriately apply vectors qualitatively to describe physical situations.
8. Use vectors to quantitatively solve problems relating to motion.
9. Create a free-body diagram to represent the total force on an object (including friction).
10. State and apply the laws of motion developed by Isaac Newton.
11. Solve problems related to static equilibrium and rotational equilibrium.
12. Apply the Law of Universal Gravitation to objects moving in circles.
13. Calculate the work done on an object and its relationship to energy.
14. Quantitatively and qualitatively describe systems in which energy is conserved.
15. Identify the various sources of energy and power.
16. Solve problems related to impulse and the Conservation of Momentum.
17. Apply principles of fluid dynamics to describe phenomena in nature.
18. Distinguish between heat and temperature.
19. Identify the ways that heat can be transferred between two points.
20. Explain the distinguishing characteristics of solids, liquids, and gases.
21. State the laws of thermodynamics and their importance to technology.
22. Solve problems relating to periodic (cyclical) motion.
23. Describe the properties of sound waves with respect to pitch, volume, and intensity.
24. Apply the Doppler Effect to physical situations quantitatively and qualitatively.

Variations

Showcase Portfolios

A showcase portfolio is a limited portfolio where a student is only allowed to present a few pieces of evidence to demonstrate mastery of learning objectives. Especially useful in a laboratory course, a showcase portfolio might ask a student to include items that represent: (i) their best work; (ii) their most interesting work; (iii) their most improved work; (iv) their most disappointing work; (v) and their favorite work. Items could be homework assignments, examinations, laboratory reports, news clippings, or other creative works. An introductory letter that describes why each particular item was included and what it demonstrates makes this type of portfolio especially insightful to the instructor.

Checklist Portfolios

A checklist portfolio is composed of a predetermined number of items. Often, a course syllabus will have a predetermined number of assignments for students to complete. A checklist portfolio takes advantage of such a format and gives the students the choice of a number of different assignment selections to complete in the course of learning science. For example, instead of assigning exactly 12 sets of problems from the end of each text chapter, students could have the option of replacing several assignments with relevant magazine article reviews or laboratory reports that clearly demonstrate mastery of a given learning objective. Additionally, class quizzes and tests can become part of the portfolio if that is what is on the checklist of items to be included. A sample checklist might require a portfolio to have 10 correctly worked problem sets, two magazine article summaries, two laboratory reports, and two examinations in addition to self-reflection paragraphs where the student decides which objectives most closely fit which assignments.

Open-Format Portfolios

An open-format for a portfolio generally provides the most insightful view of a student's level of achievement. In an open-format portfolio, students are allowed to submit anything they wish to be considered as evidence for mastery of a given list of learning objectives. In addition to the traditional items like exams and assignments, students can include reports on museum visits, analysis of amusement park rides, imaginative homework problems, and other sources from the ”real world”. Although these portfolios are more difficult for the student to create and for the instructor to score, many students report that they are very proud of the time spent on such a portfolio.

Use in Large Enrollment Courses

Portfolios can be used successfully in large courses provided there is an infrastructure for students and instructors to utilize. Most importantly, the format of each item in the portfolio needs to be in a similar format; the use of cover sheets, forms, and prescribed notebooks often helps. Second, students creativity must be sacrificed to some degree for the sake of uniformity. This can be accomplished by assigning student tasks that have fewer multiple-correct solutions. Finally, if graduate teaching assistants are used, each assistant should take responsibility for a particular series of learning goals, thus becoming an expert and seeing all student submissions. If announced to the students, this helps curtail academic dishonesty and variation in scoring.

Analysis

Because each portfolio is individualized, student assessment must be compiled by looking at the portfolio's contents relative to the course learning objectives. Each piece of evidence should be graded according to a predetermined scheme. The items can be scored discretely as a 0, 1, 2, or 3 based on the grader's judgment about the student's presentation as related to the stated learning goals. (A larger scale can be used, but the reliability of different faculty giving the student the same score decreases.)

Figure 2: Illustrative Grading Criteria for Portfolios

Grading Criteria

Each individual piece of evidence will be graded according to the following scale:

- **Score 0: No evidence** - the evidence is not present, it is not clearly labeled, or there is no rationale or self-reflection.
- **Score 1: Weak evidence** - the evidence is presented is inaccurate, implies misunderstandings, has insufficient rationale or insufficient self-reflection.
- **Score 2: Adequate evidence** - the evidence is presented accurately with no errors nor misunderstandings implied, but the information is dealt with at the literal definition level with no integration across concepts. Opinions presented are not sufficiently supported by referenced facts or facts are presented without clear relevance to opinions or positions.
- **Score 3: Strong Evidence** - the evidence is presented accurately and clearly indicates understanding by integration across concepts. Opinions and positions are clearly supported by referenced facts.

Grading Rubric

The overall portfolio is scored as follows as an indication of the extent to which the portfolio indicates that the student has mastered the 15 course objectives listed elsewhere in the syllabus:

Grade:	Rubric:
A	Strong evidence in at least 12 objectives; adequate in other three
B^+	Strong evidence in at least 12 objectives; adequate in at least one other;
B	Strong evidence in 10 objectives; adequate in all others;
C^+	Strong evidence in 9 objectives; adequate in others;
C	Strong evidence in 9 objectives; adequate in at least one other;
D^+	Adequate evidence in 12 objectives;
D	Adequate evidence in 10 objectives;
F	Adequate evidence in less than 10 objectives;

Submission and Possession of Evidence:

Submission of evidence for mastery of each objective is to be done during laboratory class meetings and the portfolios will be securely maintained in the laboratory. It is your responsibility to see that your portfolio is current and accurate. No late submissions will be accepted. Any submissions remotely suspected of plagiarism will receive a score of 0.

Evidence scored as a 0 or a 1 is rather straightforward based on the criteria listed in figure 2. The most difficult judgment usually lies between awarding a score of 2 and a score of 3. In particular, a score of 2 is awarded if the student has addressed the learning objective correctly and clearly, but only at the literal-descriptive level; there is little explicit integration across concepts or indication of relevance to the student. A common characteristic of such evidence is that facts are not used to support an opinion or position. Furthermore, evidence that does not clearly identify relevance to the student's life or career path is also given a score of 2. To be awarded a score of 3, the evidence must clearly indicate that the student understands the objective in an integrated fashion. Such evidence provides the reader deep insight into the complexity of the student's comprehension.

Viewing student portfolios from this perspective drastically changes the emphasis from collections of facts to encompassing concepts. Such a grading procedure also shifts responsibility for demonstrating competence from the instructor to the student. Effectively shifting this responsibility affects comments placed in the portfolio by the grader; comments are directed toward improving the next submission as well as indicating the inadequacies of the current evidence.

Pros and Cons

- Portfolios put the responsibility of demonstrating knowledge and integration across concepts on the students
- Portfolios provide a structure for long-duration assignments
- Portfolios encourage student creativity and allow for students to emphasize the aspects of a concept most relevant to them in meaningful ways
- Portfolios engender self-reflection and self-assessment

However:

- Portfolios take longer to score than machine graded multiple-choice exams
- Portfolios involve student work outside of class
- Portfolios do not easily demonstrate students' knowledge-recall abilities
- Students who have been successful at memorizing their way to an "A" initially find portfolios intimidating

Theory and Research

Today, it is generally recognized that the commonly used series of 60-minute examinations can only provide an instructor with a quick and limited view of the knowledge a student has actually achieved during a semester course (Slater, 1997). Conventional multiple-choice tests do not provide the instructor with enough information to ascertain why the student gave a particular response. Unfortunately, even student-supplied responses, in-class essays, and quantitative problem-oriented test items are severely limited in scope and complexity due to unavoidable time constraints. These deficiencies and others have previously been thoroughly described and documented (Berlack et al., 1992, p. 8).

Portfolio assessment strategies, such as those used in fine arts such as photography, architecture, and writing, might hold the most promise for earth science instruction. In the introductory level science course, portfolios provide a forum for extended and complex learning activities and observations (Slater, 1994; Collins, 1992; 1993). For example, an introductory geology portfolio might contain maps drawn by the student, cross-sections, and interpretations from student observations. The student can also provide an indication pertaining to some of the difficulties encountered in obtaining information and justification for any assumptions employed. In such a procedure, much of the responsibility of both learning and assessment is transferred to the student.

In terms of effectiveness, Slater (1997) reports how different types of portfolios in three separate classroom contexts were used to explore the effectiveness of portfolio assessment strategies. In each study, a two-group comparison strategy was used and the groups were compared on several measures. These included a common final examination and a pretest/posttest self-report survey. Additionally, each group that used portfolios completed open-ended surveys and participated in focus group interviews. Three classroom contexts were used: (1) college physics at an urban community college; (2) physical science for elementary education majors at medium-sized university; and (3) introductory environmental science for non-science majors in a large-enrollment lecture course ($n > 280$) at a major university.

For each study, one of two course sections was randomly selected to be assessed primarily by portfolios while the other was assessed traditionally using quizzes and tests. With the exception of the final examination, students who were primarily assessed using portfolios were not administered any of the quizzes or tests that the traditional students took. Student portfolios were evaluated at regular intervals throughout the semester using a holistic scoring rubric (described thoroughly by Rischbieter, Ryan, & Carpenter, 1993; Astwood & Slater, 1996; Kuhns, 1993). At the end of the semester course, all students took the same multiple-choice final examination with 24 to 50 items that were directly correlated to the course learning objectives.

In each study, the results were essentially identical. Students assessed by portfolios scored just as well on a traditional multiple-choice final examination as their traditionally assessed counterparts. However, an analysis of the qualitative data suggests that, from the students' perspectives, there may be major advantages to the portfolio assessment strategy.

All students completed open-ended surveys and representatives from each class using portfolios participated in focus group interviews. Overall the students reported that they liked this alternative procedure for assessment. Probably most important to the students, the portfolios significantly reduced the level of "test anxiety" (Slater, Samson, & Ryan, 1995). This reduction in student anxiety clearly shows up in the way that students attend to class discussions. Students suggest that they feel like they are being relieved of their traditional vigorous note taking duties so they are free to look at the holistic science of a given situation - not just the formulas. They state that they enjoy class discussion more because of the atmosphere promoted by the assessment strategies employed.

Students assessed by portfolios also report that they spend a lot of time going over the textbook or required readings to be sure that they comprehend the depths of each learning objective. Although it is unclear exactly how much time students devote to creating their portfolios, they do report that they contemplate the concepts outside of the classroom environment - always looking for that "neat thing" to include in their portfolio. Students reported that they thought that would remember what they were learning much better and longer than they would the material for other classes they took. Students suggest that this is because they have internalized the material while working with it, thought about the principles, and applied concepts creatively and extensively over the duration of the course.

Links

- Timothy F. Slater, Research Assistant Professor of Physics, Montana State University. Interests: authentic assessment in support of student-centered instruction; physics/astronomy education at both K-16 levels and public awareness; Internet-based scientific investigations involving real-time earth/space science data; and teacher-enhancement. solar.physics.montana.edu/tslater

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Tim Slater

While I was a graduate teaching assistant in astronomy, I sympathized with students who told me that there were two ways of taking college science classes. One was to learn and understand the material and the other was to get an "A." The students well understood that the most productive strategy for getting a high grade in most introductory science courses involved memorizing the notes from lecture, working enough homework problems so that the proper algorithm could be applied to the corresponding problem on exams, and subsequently forget everything they had temporarily memorized.

Eventually, I began to understand for myself that I was not going to take a multiple-choice examination to pass my Ph.D. defense anymore than my tenure and promotion as a faculty member would depend on how many facts I had memorized. I realized that what I loved about doing science was DOING science and focusing on the aspects most interesting to me. About that same time, the National Council for Teachers of Mathematics (NCTM) began to extol the virtues of alternative assessments as a way of moving students beyond memorizing procedures and motivating them to understand concepts. I began exploring ways to adapt the procedures already well understood in the fine arts areas (photographers always have a portfolio) to the excitement of scientific inquiry. Over the years, I have used portfolios at a variety of levels of seriousness; even at one point discarding examinations in total. I now believe that, in the same way that students must actively construct their own knowledge with considerable mental effort, the creation of portfolios support student-centered instruction better than any short-duration examination that I can imagine.