Portfolio assessment strategies for grading first-year university physics students in the USA

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Accompanying the new US curriculum standards and guidelines are new grading and assessment strategies. Three types of portfolio assessments being utilized are Showcase Portfolios, Checklist Portfolios and Open-Format Portfolios. This alternative grading strategy supports student learning on conventional examinations and appears to have additional benefits.

Several US organizations have recently published new curriculum guidelines for secondary science students. These curriculum frameworks from such large organizations as the American Association for the Advancement of Science (Project 2061), National Science Teachers Association (SS&C), National Science Education Standards Project and Earth Systems Education, among others, clearly state that learning about the nature of science, inquiry methods and relationships between science, technology and society are far more important than learning random facts and formulae (Carpenter 1993). Although quite common in the US, conventional examinations using multiple-choice items and simple student-supplied response questions are likely to be insufficient to measure student understanding of the aforementioned concepts.

Science educators are beginning to recognize that a small 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 (Tobias and Raphael 1995). Conventional multiple-choice tests do not provide the instructor with enough information to ascertain whether the student gave the correct response using information gathered from intensive studying, faulty reasoning or merely luck. 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. Short duration questions cannot assess students’ high-level cognitive processes. These deficiencies and others have previously been thoroughly described and documented elsewhere (Berlack et al 1992).

Introductory students in the US, especially non-science majors, often complain that introductory courses lack relevance to what students consider to be ‘real life’. These students are correct in that courses that require little more than memorizing vocabulary words and formulae or recognizing trivial scenarios are certainly not immediately relevant to most students. Multiple-choice test items often subtly convey the impression that science is merely a large collection of facts. If we want students to view science as a process of describing the world, our grading strategies need to emphasize process. Assessment strategies should reflect the new curricula’s emphasis on the integration of scientific knowledge with the aspects of technological advances and the influences of society.

Advantages of Portfolio Assessment

In an effort to respond to the needs of the new US curricula, educators have been developing a number of alternative assessment procedures to be used in concert with traditional examinations. These alternative strategies provide a forum in which more lengthy and authentic assignments can be used. An authentic task is one in which students are required to address problems grounded in real-life contexts.
Such tasks are typically complex, somewhat undefined, engaging problems that require students to apply, synthesize and evaluate various problem solving approaches (Shavelson et al 1991, Slater and Ryan 1993, Wiggens 1989, Wolf 1989). These approaches are gaining popularity in the US, particularly in mathematics. Currently, there are a small, but growing, number of applications in first-year physics.

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. Most importantly, portfolios are more than thick folders containing student work; they are personalized, longitudinal representations of a student’s own efforts and achievements (Collins 1992). Whereas multiple-choice tests are designed to determine what the student doesn’t know, portfolio assessments emphasize what the student does know. Just as artists carry samples of their best work in their portfolio, student portfolios can contain carefully selected items which demonstrate their mathematics and scientific knowledge (Kuhs 1994).

Appropriate use of portfolio-style assessment strategies can also increase the rigour of an introductory science course. Students have to do more than memorize lecture notes and text materials because of the active creation process involved in preparing a portfolio. They must organize, synthesize and clearly describe their achievements and effectively communicate what they have learned. Such a process requires time-consuming student-introspection and a certain degree of self-assessment. The primary benefit gained from creating a portfolio of this nature is that the integration of numerous facts to form broad and encompassing concepts is actively performed by the student instead of the instructor.

**Student self-reflection**

A successful portfolio 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 clear to the reader the processes of integration that have occurred during the learning process. Often, this can be achieved with an introductory letter to the reader or as a summary at the end of each section. Moreover, such reflections ensure 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.

**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 physics 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 favourite 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 physics. 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 ten correctly worked problem sets, two magazine article summaries, two laboratory reports and two examinations in addition to self-reflection paragraphs (Slater and Astwood 1995).
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
physics 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 (Slater 1994).

Portfolio scoring
A student portfolio represents achievement relative
to specific learning objectives which need to be
clearly stated. 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 judged subject to the
'modified holistic' scoring rubric shown in the box
(adapted with permission from Rischbieter et al
1993). Each piece of evidence submitted is assigned
a holistic score of 0, 1, 2 or 3 based on the grader’s
judgment about the student’s presentation as
related to features of the defined learning
dimensions.

Evidence scored as a 0 or a 1 is rather distinct based
on the criteria listed. 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 characteristic of such evidence is that
facts are not used to support an opinion or position.
Furthermore, evidence which does not clearly
suggest that the material is relevant to the student
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 uses facts to support
opinions or positions and further provides the reader
insight into the complexity of an issue. Finally, the
evidence presented should indicate the relevance of
the learning objective.

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

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**Portfolio Scoring Criteria**
Each individual piece of evidence will be scored
according to the following scale:

**Score 0: No evidence:**
the evidence is not present, it is not clearly labelled 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 scheme**
The overall portfolio is scored as follows as an
indication of the extent to which the portfolio
indicates that the student has mastered the 14 course
objectives listed elsewhere in the syllabus:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Strength of evidence for a total of 14 objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Strong in 11; adequate in 3</td>
</tr>
<tr>
<td>B+</td>
<td>Strong in 11; adequate in 1</td>
</tr>
<tr>
<td>B</td>
<td>Strong in 10; adequate in 3</td>
</tr>
<tr>
<td>C+</td>
<td>Strong in 9; adequate in 5</td>
</tr>
<tr>
<td>C</td>
<td>Strong in 9; adequate in 1</td>
</tr>
<tr>
<td>D+</td>
<td>Adequate in at least 12</td>
</tr>
<tr>
<td>D</td>
<td>Adequate in at least 9</td>
</tr>
<tr>
<td>F</td>
<td>Adequate in less than 9</td>
</tr>
</tbody>
</table>

Note. Adapted, with permission, from Rischbieter et al (1993).
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. Although such a procedure appears to be time-consuming, many instructors are finding it to be consistent with traditional grading practices and significantly less boring.

**Student perceptions of portfolios**

Students' perceptions have been gathered in several studies through formal interviews, focus group discussions and open-ended written surveys. Although the data and analysis are beyond the scope of this paper, students often have very similar feelings concerning portfolios (Astwood and Slater 1996, Barrow 1995, Slater 1994, Slater and Privett 1993, Slater et al 1995). Most students interviewed and surveyed report that, overall, they like this alternative procedure for assessment. Possibly the most important aspect to the students is that the portfolios significantly reduced their perceived level of 'test anxiety'. Students reported that they 'freeze up' or 'forget everything' when they sit down to take a conventional examination. Simply having a list of formulae provided doesn't appear to reduce this anxiety much. The portfolio style of assessment seems to remove this perceived testing anxiety. This reduction in student anxiety clearly shows up in the way that students attend to class discussions. The students suggested that they are not nearly as worried about permanently remembering what each variable represents because they will look that up in the text later if necessary. 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 physics of a given situation, not just the formulae. They state that they enjoy class discussion more because of the atmosphere promoted by the assessment strategies employed.

During class discussions, students seem to be trying to figure out just how they might be able to apply the current in-class discussion in their portfolio by actively seeking to compare the discussion with their outside-of-class experiences. The students readily describe how, in many traditionally assessed classes, they would write down everything the teacher says, memorize it for the test and forget it. During the interview, participants concluded that they thought that they would remember what they were learning much better and longer than they would the material for other classes they took because they had internalized the material while working with it, thought about the principles, and applied physical science concepts creatively and extensively over the duration of the course.

From the students' perspectives, the most negative aspect of creating a portfolio is that they spend a lot of time going over the textbook or required readings (Safko and Slater 1994). This is because they need 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 physics outside of the classroom environment — always looking for that 'neat thing' to include in their portfolio. As with any endeavour, the amount of time that a student devotes to his or her studies varies considerably with each individual student. The creation of a portfolio does appear to require a robust combination of sustained effort on the part of the student and reflection concerning what is really the salient points of a class discussion, and brings about an attempt by the student to grasp the holistic view of a physics concept.

**Discussion**

Instead of just passively memorizing the formulae and problem-solving routines, many students become active learners while creating portfolios. The act of constructing their knowledge encourages students to view science as a method of inquiry rather than a long list of facts to be memorized. Comparisons in several contexts indicate that students who spend time on portfolios score just as highly as students who do not create portfolios (Astwood and Slater 1996, Slater 1994, Slater and Privett 1994, Slater et al 1995). However, students enthusiastically report that they are enjoying time spent on creating portfolios and that they believe it helps them learn physics concepts.

**References**

Astwood P M and Slater T F 1996 Portfolio assessment in large enrollment courses:
effectiveness and management  

J. Geol. Educ. at press

Barrow D A  1995  The use of portfolios to assess student learning  
J. College Sci. Teach.  22 211–4

Carpenter J R  1993  An overview of geoscience education reform in the United States  
J. Geol. Educ.  41 304–11

Collins A  1992  Portfolios for science education: issues in purpose, structure, and authenticity  
Sci. Educ.  76 451–63


Kuhs T M  1994  Portfolio assessment: making it work for the first time  
Math. Teacher  87 332–5

Rischbieter M O, Ryan J M and Carpenter J R  1993  Use of microethnographic strategies to analyze some affective aspects of learning-cycle-based minicourses in paleontology for teachers  
J. Geol. Educ.  41 208–18


Appl. Meas. Educ.  4 347

Slater T F  1994  Portfolio assessment strategies for introductory physics  
Phys. Teacher  32 415–7

Slater T F and Astwood P M  1995  Strategies for grading and using student assessment portfolios  
J. Geol. Educ.  45 216–20

Slater T F and Privett J  1994  Portfolio assessment in physical science for elementary education majors. Paper presented at the meeting of the South Carolina Academy of Science, Aiken, SC

Slater T F and Ryan J M  1993  Laboratory performance assessment  
Phys. Teacher.  31 306–9


Tobias S and Raphael J  1995  In-class examinations in college science — new theory, new practice  
J. College Sci. Teaching  24 240–4

Wiggins G  1989  A true test: toward more authentic and equitable assessment  
Phi Delta Kappan  70 703–13

Wolf D  1989  Portfolio assessment: sampling student work  
Educ. Leadership  46 35–7