Portfolios in Science Education

Craig B. Rohrbough

This paper was completed and submitted in partial fulfillment of the Master Teacher Program, a 2-year faculty professional development program conducted by the Center for Teaching Excellence, United States Military Academy, West Point, NY, 2010.

Key Issues

Course portfolios were traditionally used in the arts to showcase a student's progression and to demonstrate the student's work. Educators seeking alternatives to testing have applied portfolios to other disciplines, including science education in college. Portfolios provide instructors with another method to evaluate students' learning as well as an opportunity to assess how effectively the course is accomplishing its goals. While it may not be appropriate for portfolios to completely replace end of course exams, they provide an alternate approach to evaluation that allow students to demonstrate their knowledge. Portfolios also provide the students an opportunity to achieve synthesis and evaluation through the creation of the portfolio, which requires reflection. Very few studies have been done specifically for the use of portfolios in science education, and the largest one to date was limited to introductory science classes. However, laboratory programs have a history of using laboratory notebooks, a practice which could possibly extend to the creation of portfolios, and there are valuable learning opportunities in the creation of a portfolio that may be applicable to upper level science courses.

History of Practice

Educators looking for a method to evaluate deeper learning saw that portfolios allowed evaluation of a student's ability to create, evaluate and analyze. Traditional testing evaluates simple recall but does not necessarily require critical thinking (Wiggens, 1989). From the start of using course portfolios in science, educators wanted more than a collection of course material. To avoid the creation of an unwieldy collection of every piece of the student's work, the instructor needed to restrict the scope of the portfolio by limiting the number of pieces and determining a focus for the portfolio (Kuhs, 1994). A large study (Slater, 1997) compared students assessed by portfolios and a control group of students assessed by quizzes and testing. The study included community college students taking introductory physics, education majors taking physical science at a medium sized university, and liberal arts majors taking environmental science at a major university. At the beginning and end of the study, students from each group were tested by traditional means to determine if students evaluated by portfolios could perform as well in traditional testing.

Practice Variations

Portfolios provide instructors with a great deal of flexibility in how they are implemented. In his Classroom Assessment Technique, Slater presents four ways to implement portfolios: showcase, checklist, open format, and large enrollment courses, which require standardized formatting and

some degree of restriction to open responses which can have multiple correct answers. Open format, in particular, give the student great latitude in demonstrating their knowledge of the subject, and could include “real world” worked physics problems. Another approach is to categorize a portfolio as a collection of artifacts, reproductions, attestations, and productions (Collins, 1992). Artifacts are selections of work produced by the student throughout the course, such as papers and lab reports. In science education, lab reports would be particularly valuable as artifacts, and maintaining them in a portfolio could allow students to see how the lab program was integrated into the course as a whole. Reproductions would be work not normally captured by a course, such as videos of presentations and pictures of displays. Attestations are awards or letters to the student relevant to the course portfolio. Productions are work generated specifically for the portfolio: goal statements explaining why particular pieces of work were selected, reflections, and captions on previous work explaining the work in the context of the portfolio.

Beneficial Attributes

Portfolios provide both assessment and evaluation of the students’ learning. Students evaluated throughout a course by portfolios can score on tests as well as students who were evaluated by traditional testing during the course (Slater, 1997). However, surveys taken during Slater’s study found that students creating portfolios enjoyed the course far more, experienced less test anxiety, and spent time analyzing the conceptual aspect of the course outside of class. Additionally, instructors saw that students in the portfolio group spent their time trying to apply what they were learning to experiences outside the classroom, in contrast to the control group. However, the advantages portfolios provide to students will not lead them to expend significant time without external motivation. Despite students acknowledging the benefits of portfolios, portfolios not submitted for grade get significantly less effort (Struyven, 2005). Portfolios also provide a forum to show the full breadth and depth of their learning throughout the course (Klassen, 2006).

Controversial Aspects

Even proponents admit that there are difficulties with the implementation of portfolios for evaluation. A large scale survey on the implementation of using portfolios in Vermont revealed a significant problem in consistent scoring of student work (Koretz, 1998). It is reasonable to believe that variations in grading would persist in a large introductory science course taught by a number of instructors, although a small course taught by a single instructor would not experience the same difficulty. In elementary school portfolios, significant problems arose when trying to determine how much work was the student’s own (Gearhart, 1995). This problem would be likely to arise in college science classes as well, particularly with the wide availability of

information on the internet. Additionally, some critics assert that portfolios, as well as other evaluation methods other than traditional testing, fail to determine whether the students are able to recall information they would be expected to know by the end of a course (Terwilliger, 1997).

Conclusion

Portfolios appear to provide a valuable additional tool in science education. In particular, laboratory courses may provide an excellent forum in which to implement portfolios. Laboratory reports would be ideal artifacts for a portfolio and provide ample opportunity for productions such as reflections on what the student learned from the lab after the initial submission. Reports consolidated into a portfolio could provide students with valuable review and the opportunity for deeper learning through reflection. Portfolios provide an alternate means for educators to both evaluate students and assess learning, but should be used with caution and in conjunction with other methods. Studies have demonstrated significant questions about the validity of portfolio grades. Portfolios may have the most value in small enrollment courses, where issues in consistent grading among different instructors will not arise. They take considerable effort on both the student's and instructor's part and time needs to be allocated in the course for their creation, which reduces the time available to students for class preparation. This may mean that the deeper learning provided through portfolios would need to be offset by reducing the scope of the course. For maximum benefit, the instructor should clearly articulate the standards and purpose for the portfolio. Additionally, testing should remain one aspect of the student evaluation to ensure the students can recall and apply the information and principles taught in the course with limited access to references. By accounting for the shortcomings of portfolio evaluation, instructors can then take advantages of portfolios. Portfolios allow instructors to see the full scope of the student's learning, provide the students with an opportunity for deeper learning, and provide both evaluation and assessment. Additional studies specific to science education are needed to gain additional insight on how portfolios would be beneficial. In particular, portfolios may have value in upper level science courses.

References:

Collins, A. (1992) *Portfolios for science education: Issues in purpose, structure, and authenticity*. Science Education, 76(4) 451-463.

Gearhart, Maryl and Herman, Joan (1995) *Portfolio Assessment: Whose work is it? Issues in the use of classroom assignments for accountability*. UCLA's Center for the Study of Evaluation &

the National Center for Research on Evaluation, Standards, and Student Testing. Winter, 1995 3-18.

Klassen, Stephen. 2006. Contextual Assessment in Science Education: Background, Issues and Policy. Science Education, 90(5) pp 820-851.

Koretz, Daniel. (1998) *Large-scale portfolio assessments in the U.S.: Evidence pertaining to the quality of measurement*. Assessment in Education: Principles, Policy and Practice, 5(3) 309-335.

Kuhs, Therese. 1994. *Portfolio Assessment: Making it Work the First Time*. The Mathematics Teacher, 87(5): 332-335.

Slater, Timothy. 1997 *The effectiveness of portfolio assessments in science*. Journal of College Science Teaching, 26(5): 315-318.

Slater, Timothy. Classroom Assessment Techniques (CATs)- Portfolios. Retrieved 19 April 2010 from the School of Education, University of Wisconsin-Madison website: http://www.wcer.wisc.edu/archive/cl1/flag/cat/portfol/portfol1.htm.

Struyven, Katrien, et al. 2005. *Students' perceptions about evaluation and assessment in higher education: a review*. Assessment and Evaluation in Higher Education, 30(4): pp 331-347.

Terwilliger, J. 1997. *Semantics, psychometrics and assessment reform: A close look at "authentic" assessments*. Educational Researcher 26:8 , pp. 24-27.

Wiggens, G. (1989, May) *A true test: Toward more authentic and equitable assessment*. Phi Delta Kappan, 70(9): 703-713.

Annotated Readings:

Brodeur, Doris, Peter Young, and Kim Blair (2002). *Problem based learning in aerospace engineering education*. Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition.
This paper addresses the use of portfolios as part of a problem based learning approach. The authors employ this approach in the undergraduate Aeronautics and Astronautics curriculum at MIT. Portfolios, design reviews, competitions, journals, and self and peer assessment are all employed to provide feedback to students throughout their learning experience. This paper presents the theory, characteristics, features, and assessment of problem based learning.

Burks, Robert. (2008) *The Student Mathematics Portfolio: Value Added to Class Preparation?* 2008 USMA Master Teacher Program Project Anthology. 46-58.
This paper discusses what is required to implement a student portfolio in a undergraduate math course. It provides lessons learned from using a student mathematics portfolio in a freshman precalculus course. Data taken indicated the portfolios improved student performance, and

students provided positive feedback that showed students generally felt that portfolios enhanced the learning experience.

Challis, Maggie. (2001) *Portfolios and assessment: meeting the challenge.* Medical Teacher. 23(5) p 437-440.
This editorial presents several approaches to portfolio development and assessment in the medical education community. It includes a seven dimension taxonomy for portfolios: Style, structure, scope, purpose, confidentiality, content, and timing. Style was categorized as descriptive or reflective, and the purpose was categorized as summative or formative. The paper concludes that portfolio assessment has its own set of strengths and weaknesses, and should not be viewed as a replacement, but as complementary to traditional assessments.

Lunsford, Eddie and Mclear, Claudia. (2004) *Using Scoring Rubrics to Evaluate Inquiry*. Journal of College Science Teaching. 34(1) p 34-38.
This article discusses how to effectively grade nontraditional assessments through the use of rubrics. Rubric development and employment with portfolios is covered. The article also discusses the need for clearly published standards for students when employing nontraditional assessments. Sample rubrics for research reports, portfolios, and concept maps are provided.

Mintzes, Joel, et al. *Assessing Science Understanding: A Human Constructivist View*. Burlington, MA: Elsevier Academic Press, 2005.
The premise of this book is that instruction and assessment are not effectively coupled in science eduation. The text discusses a wide variety of alternative assessment methods to promote conceptual understanding in students. In addition to portfolios, the book covers concept maps, V diagrams, and interviews as assessment tools. Several chapters are dedicated to portfolios.

Roecker, Lee, et al. *A Science Portfolio*. Accessed 23 March 2010 from the Berea College website: http://chemistry.berea.edu/portfolio_JCollegeScienceTeaching.pdf.
This article addresses the implementation and results of portfolios in the Chemistry Department at Berea College. It discussed portfolios as a way for students to interact with faculty, a way for students to showcase their skills, and as a model for professional development. The article identifies the greatest benefit of portfolios as assessment tools for the program to ensure all students attain acceptable levels of skill.

Shavelson, Richard, Baxter, Gail, and Xiaohong Gao (1993). *Sampling variability of performance assessments*. Journal of Education Measurement. 30(3) 215-232.
This article addresses wide scale performance assessments to determine modifications to curriculums to improve student achievement. It discusses performance assessments as samples of student performance dependent on both the task and measurement method. It finds that the results of performance assessments are dependent both on the tasks selected and methodology used to measure performance, and raises questions the validity of performance assessments, including those to determine the value of portfolios.

Spalter, Anne and Rosemary Simpson (2000). *Reusable Hypertext Structures for Distance and JIT Learning*. Conference on Hypertext and Hypermedia: Proceedings of the eleventh ACM on Hyertext and hypermedia. 29-38.

This article's primary purpose was the design of modular hypertext structures that could be arranged as needed to build online courses. It provided one way of implementing portfolios as part of a distance learning course. One of the modular structures discussed is the Notebook, which would permit reflection/collection and allow the creation of portfolios in online courses. The capabilities requirements for an online portfolio are discussed.