Session 3148

Portfolio assessment as a measure of student and program success

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Abstract

Engineering technology students are good at making things work. They are curious about the mechanical world, and tend to have a very practical viewpoint. It is sometimes difficult to encourage them to master theory. They often don't like to write. In a survey of learning styles conducted on 41 students in an introductory chemistry class at the Kansas State University - College of Technology and Aviation, 37 had a moderate to strong preference for learning information kinesthetically[1]. This contrasted with only 22 students having moderate to strong preference for learning from written material. (Most students had multimodal learning preferences.) Outcomes assessment of these students must incorporate a hands-on component in evaluation or risk missing the most effective learning method for many.

Portfolio assessment is one tool which can evaluate student learning in a variety of ways, incorporating experiences which are written, visual, and kinesthetic into a final product which is amenable to evaluation and comparison. Student work representing a variety of formats can be included. Depending on the format and objectives of the portfolio, applications in all areas of engineering technology can be evaluated for technical merit, practical applicability, or any other criterion of interest to the instructor or college.

Along with achieving program goals for assessment of student learning, portfolios support students in developing awareness of their strengths and weaknesses. In a good portfolio program, students collect their work, choose representative pieces, and reflect on this work in the final presentation of the portfolio. In this process they can address questions such as: Why was I successful with this project? What makes a good design? How did I perform in group tasks? What else am I learning that builds on this information or skill? How can I change my performance to better enable me to succeed?

In 6 semesters of using portfolios with engineering technology students in required (and often dreaded) chemistry classes, I became an avid fan of this assessment tool. Many student portfolios evaluated the connections between chemical principles and their laboratory applications. Some made connections to engineering projects they were doing in other classes. Students also reflected on their own abilities and performance. Chemical and environmental engineering technology students completed a minimum of 3 semesters of chemistry courses, and the longitudinal portfolios which they developed highlighted their increasing ability to understand both the principles of chemistry and themselves.

Portfolios can serve as assessment tools fulfilling a variety of objectives; tools which allow every type of learner to highlight success and integrate it into self-knowledge. As I evaluated their portfolios, I gained a clearer understanding of my students and how I was doing at promoting their understanding of my subject matter. I believe that carrying this out to an institutional level would allow departments or entire colleges to measure student success across the entire curriculum. Integrating a portfolio throughout the program would encourage instructors of non-engineering courses to see the applications of their subject to the fields of technology in which the students will work. This could not help but make programs stronger, students more motivated, and future employers more satisfied with their new employees.

Introduction

Each of us is an individual—we teach with a particular style, interact with students in particular ways, and have our own interests and abilities. Our students are no different. They have unique histories, goals, stories, and learning styles. As we become more knowledgeable about the ways in which our students hear, understand, interpret, and integrate ideas we can design better classes and better assessment tools. As faculty we need assessment tools which are rigorous, fair, easy to tailor to a particular course or outcome objective, and which can be evaluated or graded. Ideally, we would choose a tool which evaluates higher order or critical thinking skills, and which enhances motivation for the course or for continuing in the field. Our administrators want assessments which give perspective on program success, can be used in accreditation review when needed, and help justify any request for funds or faculty load adjustments to enhance programs. An assessment tool which could be used by students, faculty, and administration to meet a wide range of needs and expectations would be a near-perfect way to work together in improving an educational program's outcomes. Portfolio assessment is a tool which can achieve these goals.

In considering portfolios as an assessment tool for engineering technology curricula, a description of several types of portfolios is presented. The rationale, objectives, and results from several years of experience using portfolios in chemistry classes for engineering technology students will be summarized. Excerpts from student portfolios will illustrate how engineering technology students integrate hand-on activities and projects into the assessment. Finally, suggestions for implementing portfolio assessments and assessing the completed portfolios will be presented.

Background

A portfolio is a collection of student work selected for a specific purpose[2]. While visual and performance artists have used portfolios for many years, their use in other disciplines is more recent. Because the portfolio may contain many types of work in many forms, it is an ideal tool for engineering technology programs. A portfolio may reflect work in one class, one subject area, or an entire curriculum. Drawings, designs, projects, video or audio presentations, and written material can be combined to create a robust picture of a student or a program. A good portfolio tells a story of a student's success, documents the learning which came from mistakes, provides reflection on both subject matter and self, and integrates these into a whole which reads easily.

There are many ways to structure a portfolio assessment, and many uses for the result. The March 1996 issue of ASEE Prism highlights five programs which use portfolios in a math, science, or engineering curriculum[5]. These programs' use of portfolios ranges from computer projects and reflective essays in a calculus portfolio, to the Colorado School of Mines' portfolios compiled by faculty members to assess the entire curriculum. In nearly every program, the portfolio's primary value was thought to be the combination of projects and reflection.

A typical portfolio will contain three types of materials: evidence, annotations, and reflections[3]. Evidence is the specific course projects, materials, or related pieces that document the student's performance. Evidence may be work which was assigned and graded throughout the semester, group work, presentations, or work prepared specifically for the portfolio. It can be in any format—paper, digital, graphic, audio, constructed. If projects are too large to be physically included, representations of the work such as photographs, reviews, or letters of commendation could be included. Annotations are statements attached to each piece of evidence which describe what it is, why it is evidence for this portfolio, and what it is evidence of. The annotations give meaning to the pieces of evidence, much the way that a museum guide gives meaning to the exhibits. Reflections tie the evidence into an internal process of self-evaluation. The reflections summarize the evidence and trace how the chosen pieces portray growth, integration, and understanding.

The most critical part of a portfolio assessment is determining the purpose of the portfolio. What will the final product be used for? What specific knowledge or skill(s) will the portfolio assess? What types of evidence will be accepted, how many pieces should be included, and how will they be organized? If these questions are carefully considered and the requirement clearly articulated, then the outcome will be portfolios which work for their intended purposes.

Rationale and Results

I began using portfolios 4 years ago after attending a workshop on authentic assessment which described how portfolio assessment could be implemented in a math/science curriculum. My main purpose was to provide a structure for reflection. I had the disturbing feeling that some students truly did not understand why they received a poor grade at the end of a semester. I wanted students to consider what they were doing well, where they needed improvement, and how everything in the semester (or multiple semesters) fit together to combine theory and practical or hands-on work.

When I began teaching chemistry, I noticed that my students were struggling with things I thought should be easy, and sailed through other tasks which I expected they would find difficult. In particular I found that their lab skills were excellent, while tests and reports were not. Other researchers have also pointed out that the ways our students learn are very different from ours. This seemed especially true for engineering technology students. To test this, I administered a survey of learning styles to 41 introductory chemistry students at Kansas College of Technology and Aviation. The survey instrument was developed by Bonwell and Fleming at St. Louis College of Pharmacology[1] to differentiate four learning preferences or styles (Table. 1).

Table 1. VARK Learning Styles Categories

Visual (V): This preference includes the depiction of information in charts, graphs, flow charts, and other devices that instructors use to represent what could have been represented in words.

Aural (A): this perceptual mode describes a preference for information that is "heard". Students with this modality report that they learn best from lectures, tutorials, and talking to other students.

Read/Write (R): This preference is for information displayed as words. Not surprisingly, many academics have a strong preference for this modality.

Kinesthetic (K): By definition, this modality refers to the "perceptual preference related to the use of experience and practice (simulated or real)." The key is that the student is connected to reality, "either through experience, example, practice, or simulation.[4]"

Students take the survey, score themselves, and determine which preference(s) represent their learning style. While most college faculty (including the author) will show a preference for "Read-Write", in this sample of engineering technology students only 2 of the students had R/W as a strong preference, while 19 had no preference for this learning mode. Thirty-seven of the 41 students (90%) had kinesthetic learning as one preference, and 9 of these were exclusively kinesthetic learners. Most students were multi-modal, showing mild to strong preference for 2 or more styles. Traditional teaching—with lectures and books, written tests and lab reports—does not address the predominant learning style of these students. Is it any surprise that their performance was low on traditional assessments?

My requirement was for a rather simple portfolio, containing 4 pieces of evidence and a reflective essay. The reflective essay addressed 5 questions (Table 2), and concluded with a statement about the overall grade earned and a justification of this decision. This was intended to force reflection on the connection between performance, effort, and final grade. The portfolio gave the students a chance to see how things fit together in chemistry. They could highlight their strengths, address their weaknesses, include class activities from other courses which utilized or expanded on their chemistry training, draw connections, and evaluate their overall performance.

<u>Table 2: Questions to answer in your portfolio essay</u>

1. How do these four pieces reflect your progress in thinking about chemistry?
2. How do these items demonstrate your ability to integrate concepts in the laboratory?
3. Thinking of the piece which requires improvement, why does it need improvement, and what would you do to improve this piece of work if you had the chance?
4. Thinking of the piece which shows your best work, what qualities made you choose this piece?
5. Thinking of all 4 pieces, how do these pieces illustrate your ability to <u>comprehend</u> knowledge in chemistry, <u>apply</u> that knowledge, <u>analyze</u> information you have gathered, <u>synthesize</u> ideas and information, and <u>evaluate</u> the information and conclusions for accuracy?

I was convinced of the value of portfolios after the first semester, and my conviction got stronger with each succeeding class. As individuals, each student found a different aspect of the course interesting and had different areas of success or frustration. In their own words, here are a few excerpts which show some of the ways students integrated engineering and chemistry concepts, describe how reflection gives ownership to the student, and demonstrate an increased sense of responsibility for learning.

> "This piece represents how chemistry is applied in the engineering approach to process-related problems."

> "The part of this that I am most proud of is the regression analysis. In less than a week I went from being completely ignorant about regression analysis to performing it on our data. I read statistics books until I understood regression analysis and then I learned how to make the Mathcad package perform the analysis."

> "The Open House project I took on was a success in terms of getting visitors to the chemistry lab involved in photography. I am most proud of this project because of the coordination it took to bring the 6 to 8 student helpers together, teach them how to safely handle chemicals in the darkroom, and respond to visitor's questions."

> "It was not hard to find what I did the worst on, it was by far the tests. I have always known how to improve on my grade, but I have never been able to give myself drive to improve. I know that I needed to study more when it was almost test time, and I needed to read the chapters that were assigned."

> "The labs reflect the way I learn. I learn quicker with my hands and eyes. When I can do the experiments and see the reactions it is easier to understand."

> "The first piece I chose was the lab where we had to find the temperature of the water in the coffee pot. I thought this was one of the coolest labs because the method we used was my idea. I was able to use problem solving techniques that I had learned first in my Fluid Mechanics class."

> "This class helped me to understand the semiconductors class I took 2 semesters ago."

> "The tests were the low points of this class. I believe that I know the material, but I just need to get it out of my head and onto the paper. I don't do very well with tests."

> "My best work I have chosen not because it is particularly impressive (it is not), but because it is simply a reminder to me that I am capable of good work when I am reasonably confident in what I am doing. It encourages me towards the belief that, however difficult it may for me to learn, if I persist –I can learn chemistry."

> "After several lab periods, my partner and I can extract and recrystallize a product in less than 45 minutes. In the beginning of the course these procedures took 5 hours!"

> "I have worked with plastics for a number of years. This paper took a lot of time but the information I gained was very interesting. For years I knew that if an extruder malfunctioned or sat full of material too long and burned up that we were to leave the area as quickly as possible. Now I know why to run."

> "I have a problem with understanding things that I can't see, and maybe that is a small part of the problems that I have had in chemistry."

> "This class has taught me that nothing good comes from a lazy effort, and that organizing one's time is an absolute must."

> "This was a good lab. I just loved this lab, not just because I got to play with cool equipment (OK, to be honest the spectrophotometer really perked my curiosity. I just love to work with tools.) This was just a cool lab!!! I just kept thinking of different way to use this idea of absorption."

> " I have included a lab that I designed and tested for my Industrial Electronics class about light transmission. I was able to understand how the different materials that make up light emitting diodes and fiber optic cable affected how light travels."

> "This was my first time of ever flunking a course, and even though I had the courage to take it again, I felt embarrassed and ashamed to go back into that room….So, I started the year off bad again with my head down low and my grades even lower….The term paper was the first paper that I done in your class that I could be proud of. I felt that after I had done this that it was possible for me to do better and that I wasn't helpless in passing this course."

A major concern of some instructors is whether this type of assessment is a hidden form of grade inflation. To these instructors, any points awarded for work that is not subject oriented and rigorously objective are suspect. To examine this possibility, I calculated all of my grades using two algorithms. In the first calculation, the portfolio grade was not included in the final grade. In the second calculation, the portfolio counted as 10% of the course grade. I compared the two methods for the final letter grade which would have been awarded, and also for the difference between the two scores. In no instance did the portfolio grade change a final letter grade compared to the grade earned based solely on other assessments. The difference between final grades calculated with and without the portfolio ranged from a 9 % decrease when considering portfolio (for a student who failed to submit the portfolio and also had failed every test), to a 5 % increase when the portfolio grade was included. The mean was a 0.28 % decrease in final percentage, and standard deviation was 2.2 %.

An interesting result emerged when comparing the letter grade actually assigned with the grade which students thought they had earned. Of 59 portfolios submitted in two semesters, 41 predicted the same grade which was later assigned. Ten students under-estimated their grade by one letter grade. All but one of these students had final percentages within 2 % of the cutoff point for the grade they predicted. Eight students over-estimated their grade. Of these 8, four were one letter grade high in their estimates, and the other four were two letter grades off. The actual final percentages ranged from 2% below the cutoff for the estimated grade to 24% below the cutoff. All 10 of the under-estimators were A or B students (4 earned A's, 6 earned B's) while none of the over-estimators were A or B students (3-C's, 2-D's, and 3-F's). There were also 5 D and F students who did not submit portfolios. Many of these students justified their grade expectation on attendance, how hard their schedule was, turning in material on time, or simply the "effort" they expended. It appears that poorer students have difficulty realistically assessing their performance.

Getting started with portfolios

A successful portfolio program has clearly defined goals and purposes, well articulated guidelines for structuring the portfolio, a meaningful reward for the effort of doing a good job, and a manageable assessment plan[2]. It is best to start small and get comfortable with this type of assessment.

Purpose: What knowledge or skills will the portfolio document? Which of the learning objectives for the course (or curriculum) can be measured best with a portfolio? Some of the skills which might be considered are: integrating ideas, participating in group projects, using mathematics to develop models or explain data, communicating effectively to different audiences, or combining theory and design. The portfolio is particularly well-suited for assessing skills which develop over time, or in stages.

Structure: What evidence will best illustrate the purpose? What types of evidence will be accepted, how many pieces are required, and how should they be presented? Will the evidence be pieces that have received a grade already (tests, quizzes, projects) or pieces created just for the portfolio? There should be a balance between assigned pieces and student-selected pieces. You need enough similarity between portfolios to evaluate them objectively, but students need enough freedom to choose pieces and presentation that there is a sense of ownership. Individual creativity will be lost if your requirements are too structured. The consensus among educators is that a minimum of 4 and maximum of 8 – 10 pieces of evidence are required to give a meaningful picture of a student's performance.

Reward: The value of the portfolio must be related to the reward. Some programs do not assign any credit for the portfolio, but require it to pass the course or the program. These portfolios may be vested with greater value by designing them to be useful in a job search. Other programs use the portfolio as the total grade for the course. One example of this is to comment on student work throughout the semester, but reserve all grading until the portfolio is submitted. The student selects which pieces of work will be considered for the final grade and explains why. Somewhere in between these extremes is probably where most programs fall.

Assessment: "Authentic assessment should ferret out and identify strengths and enable the persons doing the assessment to show off what they do well…(they) encourage integration of knowledge and skills learned from different sources; promote pride in ownership; and include peer evaluation as well as self-evaluation. Portfolios have the potential to be a form of authentic assessment.[3]"

The stumbling block for many instructors considering portfolios is assessment. How do you fairly, objectively, and efficiently evaluate something which will be uniquely individual for every student? Assessment rubrics from a variety of programs all recommend a single holistic assessment. Many are scored on a 1-6 or 1-4 scale, with consideration given to items like voice, risk taking in content or form, excitement, organization, analysis, creativity, relationships, self-reflection, coherence, and clarity. Using portfolios for assessment of faculty members or programs will require different criteria for assessment, but should be adaptable to a similar holistic evaluation.

Summary

Portfolios allows integration of subject and application, incorporate material in many forms, encourage reflection on learning and development of responsibility, and give students authority and ownership in crafting their education. Students show off their strengths, reflect on why certain types of activities are difficult, and in the process develop an understanding of their learning style and how to improve their performance. Student portfolios are readily adapted for evaluation of curriculum or program goals through careful selection of pieces of evidence or excerpts from reflective essays. In a curriculum focused on real world application such as an engineering technology curriculum, this assessment tool has great promise for enhancing student enthusiasm and understanding.

Conclusion

I have gone from skeptic to cheerleader in the 4 years since I attended my first portfolio assessment workshop. The feedback from my students about this requirement has been almost completely favorable. I have used excerpts from the portfolios to compile ABET accreditation review documentation, justify several major budget expenditures, document the learning styles and needs of students in grant proposals, and rebuild my enthusiasm for teaching after a grueling semester. Grading them has always been a joy. This is a tool with tremendous potential for engineering technology programs.

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