A Science Portfolio

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The use of portfolios has had a positive impact on students, faculty, and the program in the Chemistry Department at Berea College. The portfolio allows for the inclusion in the curriculum of activities that occur outside of the classroom and offers a convenient means to monitor student participation in those activities. In addition to guiding students through the curriculum, the portfolio is a document that summarizes their skills, a vehicle through which they can interact with faculty, and a model for professional development. Because tasks outlined in the portfolio are linked to programmatic learning goals, portfolio assessment guides faculty in curricular development. The greatest strength of the portfolio, as it has been implemented, is as a device for program-level assessment that requires all students to attain acceptable levels of skill.

The Department of Chemistry at Berea College restructured its curriculum in 2000 to focus on preparing students to be professional scientists, lifelong learners, and competent communicators. To reach these goals required a change in student assessment from a form that relied solely on input measures (such as grades earned in courses) to one that also included a significant portion of standards-driven/performance-based assessment (Ryan and Krajewski 2002). No mechanism, however, existed within the department for faculty to document and assess student achievement—particularly with regard to activities that occurred outside of the standard classroom. Also of great concern was the fact that no mechanism existed that would help students navigate their way through the proposed curriculum. Encouraged by the use of portfolios in science (Barrow 1992; Adamchik 1996; Slater 1997; Phelps, LaPorte, and Mahood 1997) and teacher certification programs (Borko, Michalec, and Timmons 1997; Wigle and White 1998; Russell and Butcher 1999), a portfolio was chosen as the instrument to guide both students and faculty through the diverse set of activities designed to help students progress toward mastery of the learning goals. This paper describes the use of a science portfolio in the Department of Chemistry at Berea College over the last six years.

Literature testifying to the validity of portfolio assessment (Collins 1992; Naizer 1997) along with suggestions and cautions for portfolio implementation are plentiful (Bowers 2005; Reis and Villaume 2002; Willis and Davies 2002; Alexander et al. 2002). While a comprehensive review of that literature is not within the scope of this paper, several strengths and weaknesses are commonly discussed. The main strength of portfolios, in the eyes of faculty, is their use as an assessment tool of both programs and of individual students. Two advantages are noted for students. At one end of the spectrum, the portfolio is a device that documents student work. This documentation contributes to success in the competitive job market

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and allows for the awarding of academic credit for the life experiences of nontraditional students (Alexander et al. 2002). Closely tied to the documentation aspects of the portfolio are the opportunities for reflection as students demonstrate to the portfolio reviewer that learning goals have been achieved (Reis and Villaume 2002; Willis and Davies 2002). Reflection is seen as a way for students to take a more active, constructivist approach in regard to their education (Blocher, Echols, and Sujo de Montes 2003). The constructivist approach allows students to understand concepts by devices of their own creation as opposed to simply assimilating concepts as explained by a teacher (Etkina and Harper 2002).

Faculty concerns echoed in several studies relate to the issues of standards and of time (Bowers 2005; Ryan and Krajewski 2002). Standards are of concern in two ways. Which standards should be reflected in the portfolio—national, state, or institutional learning goals, and what are the grading standards to which portfolios should be held accountable? With regard to time, many faculty members don't embrace the use of portfolios due to the fear of spending large amounts of time in assessment.

While student exit interviews are overwhelmingly positive regarding portfolios, grading standards and time issues are also of concern to students. Students comment on grading inconsistencies from reviewer to reviewer (Reis and Vallaume 2002). As a capstone experience, where the portfolio is related to a specific course such as an internship or a senior seminar, some students find the requirement to compile evidence that they have achieved specific learning goals and then reflect on that evidence to be overwhelming in terms of the time it requires. Students in capstone experiences report that using a portfolio leads them to discover important aspects of themselves as learners, but this also leads some to frustration. As seniors, they have no more undergraduate courses to take in which they can apply their new skills. In terms of making the time commitment more manageable and increase potential learning, these students suggest spreading the portfolio requirements over several semesters (Reis and Vallaume 2002).

Sensitive to the time concerns of faculty and students, and being in the midst of significant curricular changes, we opted for a conservative approach to portfolio implementation. This conservative approach is manifested in several ways:

- The primary function of the portfolio is to guide students and faculty.
- Artifacts included in the portfolio are prescribed by faculty and reflection on those artifacts, when it occurs, is usually oral in nature.
- The portfolio is not graded per se, but specific portfolio requirements must be completed each term.
- The portfolio is a work in progress that takes two years to complete; the portfolio relates only to program-

FIGURE 1

Berea College Department of Chemistry learning-goal summary and rationale.
The educational program in the Department of Chemistry at Berea College has three main learning goals. Through the program students will do the following.

1. Develop into professional scientists
At the core of being a professional scientist is knowledge. Knowledge is discovered and refined through classroom, laboratory, research, and field experiences. To teach students what it means to be a professional scientist and to begin the development of that mindset within themselves, opportunities for activities outside of the traditional classroom such as attending seminars and professional meetings, along with reading and discussing the scientific literature, are required.

2. Develop into lifelong learners
Closely tied to student development as professional scientists is their preparation to be lifelong learners. Becoming a lifelong learner requires not only maintaining an interest in learning, but the confidence to independently tackle new material (Schön 1987). Faculty assist students in building confidence by working closely with students and providing them with frequent performance-related feedback (Brooks, Schraw, and Crippen 2005) as they work toward mastery (Schraw, Brooks, and Crippen 2005) of core course material, essential laboratory techniques, effective communication skills, and information retrieval, interpretation, and evaluation. The faculty frames the developmental plan by offering a curriculum that includes opportunities for student growth and guidance along with modeling the habits of the lifelong learner (Wiggins and McTighe 2005).

3. Develop into competent communicators
Becoming competent communicators involves the ability to read, write, and talk about science, along with the ability to listen to and reflect on science. Students read about science in the literature, create new science in the laboratory, or uncover new science in the field and then write for and talk about their findings to a variety of audiences. The ability to communicate in formal settings—poster sessions or slide shows—and in informal settings—the laboratory, hallway, or over dinner—to a variety of audiences (mentors, other scientists, administrators, and the general public) are essential skills required of a professional scientist. Students must learn how to use technology to enhance their ability to communicate.

References
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Schön, D.A. 1987. *Educating the reflective practitioner.* San Francisco: Jossey-Bass.
Schraw, G., D.W. Brooks, and K.J. Crippen. 2005. Using an interactive, compensatory model of learning to improve chemistry teaching. *Journal of Chemical Education* 82 (4): 637–40.
Wiggins, G., and J. McTighe. 2005. *Understanding by design.* 2nd ed. Alexandria, VA: American Society for Curriculum Development.

FIGURE 2

Summary of the Berea College science portfolio.

Completion and reflection on the portfolio will assist students to achieve departmental learning goals. The tasks described are completed over a two-year period. The time frame allows students to refine skills, take their learning into their own hands, and develop the habits of professionals and lifelong learners.

1. Students attend 12 seminars given by visiting speakers. Half-page summaries of the presentations are required to obtain portfolio credit. The summary includes the speaker's name and biographical information, the title of the talk, along with a brief explanation of the work. Portions of the seminar that are unclear are also noted. Presentations are often orally critiqued when the summary is handed in or in a subsequent class meeting. With prior permission, students are allowed to substitute a seminar from another science department. Students can also receive credit for a seminar by attending a scientific meeting if an acceptable summary for a presentation is submitted.
2. Students are required to successfully complete 20 laboratory exercises. Students select what experiments to perform in order to achieve a balanced exposure to a variety of instrumental techniques or experimental methods from the standard chemistry rubric of physical, analytical, biochemical, and inorganic chemistry. For safety concerns, in consideration of faculty expertise, and in consideration of instrument usage, the faculty selects 10 to 15 experiments each term for students to choose from. To earn portfolio credit, students must earn a 70% on the laboratory write-up in their notebook.
3. Students are required to do undergraduate research. This research experience may be on or off campus and usually occurs during the summer. Directed research with faculty during the semester or during the January short-term session at Berea College can also satisfy the requirement.
4. Students are required to prepare four papers and make six presentations. During each of their last four semesters, students are required to write a paper that reviews a paper or papers from the scientific literature. These papers increase in length from 3–4 pages for the first to 10–12 pages for the last. Presentations are made to classmates and science faculty at the end of each term. The poster format is used during the first two presentations. Students use PowerPoint to prepare a small poster (Huddle 2000) and make a five-minute presentation to the audience. For the last two presentations, students are required to use PowerPoint to project their presentation as a slide show. The third talk is 15 minutes in length and the fourth is 30 minutes in length. The remaining two presentations must relate to their undergraduate research. One talk must be on campus and students are encouraged use it as a warm-up for the required off-campus presentation. Any format is acceptable for the research presentations.
5. Students are required to read four important papers in the discipline and discuss the papers with a faculty member. We define an important paper as one that has been cited often *(http://pubs.acs.org/jacs125th/articles.html; http://isihighlycited.com; www.cas.org/spotlight/bchem.html)*. They are often older papers. In that sense, they are perhaps more fundamental than other papers students might have read and perhaps provide a more historical perspective. This exercise provides students with four more opportunities to discuss science. The one-on-one setting in our offices is the least formal of the many presentations that they do, but they must come prepared. Discussions typically last 10 to 15 minutes. Students describe the article and try to explain its importance. If students are not able to explain why it is an important paper, faculty help students to understand the basic science it describes and place it in a historical context.
6. Students must pass four proficiency examinations in the area of instrumental analysis. Students are required to pass proficiency examinations in the areas of chromatography, nuclear magnetic resonance spectroscopy (NMR), spectroscopy (non-NMR), and electrochemistry. To achieve proficiency and satisfy the portfolio requirement students must score at least 70% on a 20-question, multiple-choice examination over each topic. Students not scoring 70% re-take different versions of the examination until a passing score is achieved. Students are provided a series of lectures each term over one of these four areas. The lectures offer review of the techniques that have been described in earlier courses and also present new material. The multiple-choice format provides them with additional practice at taking multiple-choice examinations and is easy for faculty to grade.
7. Students must score in the 75th percentile on the American Chemical Society (ACS) General Chemistry Examination. Students may take this examination at any time during the last two years of school, but are encouraged take it early in preparation for other standardized examinations that they might be taking for job interviews or professional or graduate school. This requirement forces students to review fundamental principles and provides them with additional practice at taking standardized examinations.
8. Students must demonstrate proficiency in at least six software applications chosen from the following list: Microsoft Windows 2000, Macintosh OS 9, RedHat LINUX, ChemOffice, Gaussian 98, Excel, Word, Statview, PowerpPoint, Maple/Mathematica, Cricket Graph, Crystal 98.

References

Huddle, P.A. 2000. How to present a paper or a poster. *Journal of Chemical Education* 77 (9): 1152–53.

wide learning goals—it does not attempt to assess course-level goals except in the case of junior/senior-level laboratory experiences.

A copy of the portfolio is available at *http://chemistry.berea.edu.*

Despite the conservative approach we have taken, the impact on students, faculty, and the program has been significant. The portfolio has grown to serve five main purposes.

1. The portfolio is a guide for students and faculty at its most fundamental level. For students, it is a list of expectations for their last two years of college: a reminder that undergraduate research is a graduation requirement, proficiency needs to be demonstrated with several software programs, and a standardized examination needs to be passed. It lists tasks to be completed each term: five experiments, one research paper, one presentation, one faculty conversation, one pro-

ficiency examination, and seminar attendance. Students clearly see what they need to accomplish.

For faculty, the portfolio is a tool to guide performance-level assessment and development that supplements student assessment at the course level (Gilbert and Mason 2004). Evidence that students are developing communication skills can be found by evaluating the types of comments faculty make about presentations as students pass though the program (Teixeira-Dias et al. 2005). Departmental priorities for instrument replacement or repair can be set by tallying levels of instrument usage. The college's development office can be provided with information regarding the impact of donor gifts and the need for new or replacement equipment. Laboratories or lectures can be revised if it appears that students are having difficulty understanding a particular concept as judged from student scores. While program assessment remains an arduous task for faculty, analysis of portfolios in regard to learning goals provides a clear focus.

2. The portfolio is an instrument that brings faculty and students together to evaluate task-specific and learning-goal performance. Beside each portfolio task, space is provided for a project title, completion date, faculty signature, and, when appropriate, faculty comments. Faculty and students can review these comments as needed. Comments on prior presentations, for example, are particularly valuable for students to review while preparing for a new presentation.
3. The portfolio illustrates and introduces students to behaviors that are expected of professionals. Professional behaviors include reading the literature, gaining a current and a historic sense of one's field, examining the context of one's work in relationship to society, doing research, and attending and participating in meetings. These behaviors are not obvious to most students and they must be learned. Their inclusion in the portfolio helps students develop a professional mindset.
4. The portfolio provides students with documentation of their learning (Reis and Villaume 2002; Willis and Davies 2002; Alexander et al. 2002). Chemistry students at Berea College witnessed the importance of documenting their learning to more than just faculty. One year, a student took his portfolio along with him on a job interview—academically, he was an average student and the entry-level position he was interviewing for was a very good one. The interviewer was impressed with the documentation that the portfolio provided and the ability of the student to discuss its contents. The interviewer saw a clear vision of what it meant to graduate from our department and was impressed enough to offer the student the position. After observing this success story, students now take more care to make their portfolios neat and, since then, several students have taken their portfolios along on job or graduate-school interviews.
5. The portfolio and the tasks it outlines help students become independent learners and more reflective practitioners (Slater 1997; Alexander et al. 2002; Schön 1987). While the portfolio structures students' educational paths and clearly states specific tasks to be completed, within that framework students have some independence. Deciding what seminars to attend on campus and at meetings, analyzing their research in preparation for presentation, and deciding what experiments hold the most interest for them allow students to create a small portion of their own understanding of science (Blocher, Echols, and Sujo de Montes 2003). They are responsible for the maintenance of the portfolio and planning their semester in a manner that enables them to complete it.

The faculty and student perspective

The use of the portfolio has increased the amount of time that faculty interact with students. In terms of time requirements that are portfolio driven, each professor spends about 18 hours a term meeting with six students. This time includes the important paper discussions, attending student seminars, making comments on student presentations, reviewing seminar summaries, and signing off on student work. Increasing interactions with students was a desired outcome of using a portfolio—faculty cannot mentor students without interacting with them. The three hours a term spent with each student are purposeful. For example, by having the record of student performance, the portfolio helps faculty to make recommendations tailored to individual students.

It has been satisfying for the faculty to observe a great increase in student confidence, sense of professionalism, and communication skills since modifying our program. While those modifications were largely independent of the use of a portfolio, the program-level assessment provided by the portfolio ensures that all students reach acceptable knowledge and skill levels (Gilbert and Mason 2004). Weaker students, particularly those who tend to avoid faculty, can no longer remain anonymous because of the faculty interaction required to maintain their portfolio. Raising expectations for and reaching these students has been the most important result of adopting the portfolio in our department.

A good example of raising expectations is found in the required research presentations. While undergraduate research has been a departmental requirement for over 40 years, during the 1990s, for example, only about 20% of students presented their work at meetings. Most often, these students were the ones already comfortable with pub-

FIGURE 3

Chemistry portfolio.

Welcome to the Chemistry Program at Berea College! We are delighted to have the opportunity to work with you as you learn more about chemistry. To complete your chemistry major requires that you meet acceptable levels of performance in the classroom and in the laboratory. In addition, you must be able to communicate scientific ideas to others. We'll provide you with opportunities to learn the basics of chemistry, with opportunities to use state-of-the-art instrumentation, with opportunities to do research, and with opportunities to attend scientific meetings to present the results of your research.

We have many requirements to help shape you into what we believe will be a good chemist. To help you keep track of and on track meeting these requirements, we have assembled this check sheet that you are responsible for. You will need to ensure that your requirements are met. Faculty will check your progress each semester in the advanced laboratory sequence. Poor progress in meeting portfolio requirements will result in a grade of I being assigned for the particular advanced laboratory course in which you are enrolled. Keep your portfolio up to date!

Laboratory proficiencies

Your progress in the advanced laboratory course will be monitored using your laboratory notebooks and your portfolio. Each student is required to successfully complete 20 experiments from the approved list. You will decide what experiments you will do each semester. The portfolio guidelines will assist you in choosing each semester's work. The 20 experiments are spread over five chemistry disciplines and will use a variety of instrumental techniques. For an experiment to be used in meeting a portfolio requirement it must be adequately documented in your laboratory notebook and the write-up for the laboratory must receive a grade of C or higher.

In addition to completing 20 experiments, students must demonstrate an understanding of the various types of instrumentation within the department. Students will also take standardized examinations relating to the instrumentation used in each experiment and must achieve a specified score. Examinations must be repeated until a satisfactory score is obtained. Also, students must demonstrate a practical working knowledge of the instrument in question.

Approval

______________________, chair of the department of chemistry, finds that ______________________ has met the requirements of the chemistry portfolio required for graduation. Date: ______________________.

Seminar checklist

A minimum of 12 ACS (or other approved) seminars must be attended. It is suggested that these be spread out over the last four semesters of work at Berea. To earn credit for the seminar, you must turn in a half-page summary of the presentation before the beginning of your next laboratory period. The summary must include the speaker, where they are from, and the title, in addition to the summary. Late summaries will not be accepted. In addition, an instructor must sign your completed portfolio before the end of the next laboratory period.

Speaker	Title	Date/Faculty signature
1.______________	______________	______________
2.______________	______________	______________
3.______________	______________	______________
4.______________	______________	______________
5.______________	______________	______________
6.______________	______________	______________
7.______________	______________	______________
8.______________	______________	______________
9.______________	______________	______________
10.______________	______________	______________
11.______________	______________	______________
12.______________	______________	______________

Proficiency exam

All chemistry majors must pass a proficiency exam during their senior year. Students must score at or above the 75th percentile on the ACS Introductory Chemistry Examination. This exam will be offered twice each semester and must be repeated until a satisfactory score is achieved. Students failing to obtain the required score will receive a grade of I in CHM 471.

Date______________ Percentile ______________ Examination ______________Faculty signature ______________________________

Other attempts: ____

Papers

You must complete four papers—one will be in CHM 345 (Biochemistry) and the other three will be completed during advanced laboratory. The papers in advanced laboratory must be over three distinct areas of chemistry (for example, you cannot do two papers in inorganic chemistry) defined as physical, analytical, organic, inorganic, environmental, and biochemical.

Paper 1 (In CHM 345) Title ____

Area ______________________________ Date ______________ Approved by ______________

Paper 2 (ADV LAB) Title ____

Area ______________________________ Date ______________ Approved by ______________

Paper 3 (ADV LAB) Title ____

Area ______________________________ Date ______________ Approved by ______________

Paper 4 (ADV LAB) Title ______________________________

Area ______________________________ Date ______________ Approved by ______________

Oral presentations

A minimum of two formal oral presentations (one must be an oral presentation as opposed to a poster presentation) must be given on your undergraduate research project. One presentation must occur at a meeting outside of Berea. Examples of suitable venues include, but are not limited to, meetings of the Kentucky Academy of Sciences, the ACS, or the National Council of Undergraduate Research. A minimum of three additional oral presentations in conjunction with advanced chemistry courses (in the form of a poster/talk/seminar) are also required. Poor presentations will not be awarded credit—see the evaluation sheet for details of proficiency levels.

Date/Venue (formal)	Title	Faculty signature
______________________	______________________	____________
______________________	______________________	____________
______________________	______________________	____________

Date/Venue (advanced laboratory)	Title	Faculty signature
______________________	______________________	____________
______________________	______________________	____________
______________________	______________________	____________

Faculty comments on oral presentations:

Important papers in chemistry

You must read and discuss with your advanced-laboratory instructor a minimum of four key papers from a list of the most frequently cited papers in chemistry. Normally, you should read/discuss one per advanced laboratory course.

Author	Title	Date/Faculty signature
______________________	______________________	____________

Comments on discussions

1.
2.
3.
4.

Laboratory experiments/proficiency index

Instrumentation checklist

Spectroscopy (competence in four of five areas, one area must be NMR)

1. Nuclear magnetic resonance spectroscopy (six of the following):

One-dimensional experiments	^{1}H ______	^{13}C ______	APT ______
Two-dimensional experiments	COSY ______	NOESY ______	HMQC ______
Multinuclear experiments	^{31}P______	^{11}B/^{2}H/^{27}Al ______	Other ______

NMR written examination

Date ______________________ Score ________________ Faculty ____ Proficiency achieved ________________

2. Fourier transform IR spectroscopy: ATR ________ Diffuse reflectance ________Thin film ________
3. UV/visible spectroscopy: Frequency resolved ________Time resolved________
4. Flame atomic absorption spectroscopy: Air/acetylene flame________ Nitrous oxide flame________
5. Fluorescence: Excitation resolved ________ Emission resolved ________

Spectroscopy written examination

Date ______________________ Score ________________ Faculty ____ Proficiency achieved ________________

Chromatography and mass spectroscopy (competence shown in three of four areas)

1. Gas chromatography: Capillary column ________ GC/MS________
2. Low-pressure liquid: Organic solvent________ Aqueous solvent________
3. High-performance liquid: Reverse phase________ Ion exchange ________
4. Mass spectroscopy

Chromatography/mass-spectroscopy written examination

Date ______________________ Score ________________ Faculty ____ Proficiency achieved ________________

Electrochemistry (competence shown in two areas)

1. Polarography: Dropping mercury electrode ________ Voltage ramps ________
2. Voltammetry: Cyclic voltammetry ________ Stripping voltammetry ________
3. Coulometry: Mercury pool electrode ________ Pt gauze electrode________

FIGURE 3 (CONT.)

Electrochemistry written examination
Date ____________________ Score _____________ Faculty ___________________________________ Proficiency achieved ______________

Computational tools (competence with at least six applications)
Microsoft Windows______ Macintosh OS ______LINUX _______Excel ______Word______Statview______PowerPoint ______
Maple/Mathematica ______Cricket Graph______ Gaussian 98______Crystal 98 ______ChemOffice______ Kaleidograph ______Vacuum line ______

Experiment checklist (20 experiments are required)
Organic chemistry (must perform at least three experiments/two must be multistep syntheses)
1. Experiment ______________________________ Course___________________ Faculty signature ____________________________________
2. Experiment ______________________________ Course___________________ Faculty signature ____________________________________
3. Experiment ______________________________ Course___________________ Faculty signature ____________________________________

Physical chemistry (must choose at least six from the approved list/2 in each of the following areas)
Kinetics
4. Experiment ______________________________ Course___________________ Faculty signature ____________________________________
5. Experiment ______________________________ Course___________________ Faculty signature ____________________________________
Thermodynamics
6. Experiment ______________________________ Course___________________ Faculty signature ____________________________________
7. Experiment ______________________________ Course___________________ Faculty signature ____________________________________
Quantum chemistry
8. Experiment ______________________________ Course___________________ Faculty signature ____________________________________
9. Experiment ______________________________ Course___________________ Faculty signature ____________________________________

Inorganic chemistry (must perform three inorganic experiments/at least one advanced)
10. Experiment _____________________________ Course___________________ Faculty signature ____________________________________
11. Experiment _____________________________ Course___________________ Faculty signature ____________________________________
12. Experiment _____________________________ Course___________________ Faculty signature ____________________________________

Biochemistry (must perform four biochemistry experiments/two basic/two advanced)
13. Experiment _____________________________ Course___________________ Faculty signature ____________________________________
14. Experiment _____________________________ Course___________________ Faculty signature ____________________________________
15. Experiment _____________________________ Course___________________ Faculty signature ____________________________________
16. Experiment _____________________________ Course___________________ Faculty signature ____________________________________

Analytical chemistry (must perform two analytical experiments)
17. Experiment _____________________________ Course___________________ Faculty signature ____________________________________
18. Experiment _____________________________ Course___________________ Faculty signature ____________________________________

Other experiments (must perform two other experiments in areas of your choosing)
19. Experiment _____________________________ Course___________________ Faculty signature ____________________________________
20. Experiment _____________________________ Course___________________ Faculty signature ____________________________________

lic speaking and more confident in their abilities as scientists. Students lacking the confidence in themselves were not required to grow. The seemingly small requirement of research presentations has a far-reaching effect. Now that students are required to speak in public about their work, they work harder in the laboratory, make more effort to see how their work fits into a larger picture, maintain closer contacts with mentors when the summer is over, and pay more attention to the work of others. All students develop as scientists, professionals, and communicators—particularly those who previously would have opted to avoid the stressful encounter of public speaking.

Faculty find the portfolio to be a concise and effective instrument to document student activities, particularly those that occur outside of the regular classroom. Without the portfolio, someone in the department would need to monitor those activities. Through their portfolios, students monitor their own activities, thus freeing faculty to engage in more meaningful tasks. During the first few years of using the portfolio, however, faculty were frustrated by student procrastination. Faculty would be overwhelmed at the end of each semester with requests for the names of seminar speakers, to sign off on student work, and for appointments to discuss important papers. To avoid this problem, faculty now set deadlines for the various tasks to be completed throughout the semester and require students to obtain faculty signatures within a week of task completion.

Surprisingly, the freedom built into the portfolio has been the most unsettling aspect for many students. The most significant example relates to the 20 laboratory experiments that students are required to complete. Students continue to ask faculty, “What experiment should I do?" Faculty continue to respond, "It depends on your portfolio—review it and see what discipline or instrumental technique you are lacking." The shift from freshman and sophomore laboratories, where students were always told what to do, to now having to decide for themselves what to do, causes a great deal of angst in many students. Students are encouraged to find and complete experiments that are of interest to them but not on the faculty list. Very few students have ever done so.

Students have been asked to comment on the use of portfolios during senior exit interviews. During the first two years of use, students saw little connection between the portfolio and our educational vision. What made it difficult for students was that much of the portfolio was anchored to a sequence of new laboratory courses. Problems encountered while implementing the new courses overshadowed the benefits of the portfolio. Now that the added courses run more smoothly, the portfolio is a more natural component of the sequence and is no longer seen as a burden by students. Many students possess a sense of pride over the accomplishments documented in their completed portfolios. In years when student portfolios are kept for evaluation, many students insist that they keep the original and provide a copy to the department.

By design, our use of the portfolio has been rather conservative, particularly in comparison to the extensive use of portfolios in teacher-education programs, with regard to documentation of student work and as a means for self-reflection (Reis and Villaume 2002; Willis and Davies 2002). Changes could easily be made that would enable the portfolio described here to document a greater portion of student work. Making it part of a larger collection of materials that perhaps includes a resume, re-

FIGURE 4

Oral communication evaluation form and rating scale.

Chemistry Department oral communication evaluation form

Students must attain a rating of "proficient" in order for the presentation to count toward the portfolio requirement.

Student's name______________________________ Date____________________

Venue______________________ Evaluator____________________

Each of the following should be rated as being at a distinguished (D), proficient (P), apprentice (A), or novice (N) level. These ratings are described below.

Communication-skill assessment

A. Presence (voice, pace, eye contact, confidence, body language) ______

B. Use of supplementary material (chalkboards, handouts, overheads) ______

C. Clarity of talk (outline, organization, conclusion, appropriateness for audience) ______

D. Response to questions ______

General comments

Specific recommendations for communication-skill improvement

Technical assessment

A. Understanding of material ______

B. Explanation of material (appropriate for level of audience, educational) ______

C. Substance (technically correct) ______

D. Response to questions ______

General comments

Specific recommendations for improving technical content

Overall rating of presentation

Distinguished____Proficient_____Apprentice_____Novice_____

Explanation of rating scale

Distinguished: The oral communication skills of the student are nearly perfect. The presentation was well rehearsed with an exceptionally clear thesis and outline. Appropriate use has been made of supplementary material—writing on the chalkboard or overheads is legible, handouts add significantly to the presentation. Voice projection and the pace of the presentation are fine. Technically, the student has taken the material beyond a mere literature review or research summary by adding additional interpretation or making comparisons not present in the original literature.

Proficient: The oral skills of the student are at an acceptable level. Appropriate use has been made of supplementary material—writing on the chalkboard or overheads is legible, handouts add significantly to the presentation. Voice projection and the pace of the presentation are fine. The only minor errors that are present could be improved through additional practice. NO technical errors are present. The student has presented the reviewed material concisely, accurately, and at an appropriate level for the audience.

Apprentice: Key features of oral communication are evident, but additional development is possible. No more than one major flaw is contained in the presentation such as lack of voice projection, poor overhead usage, inappropriate body language, or poor quality of supplementary material. The thesis and outline of the talk are obvious. Technically, the presentation contains few flaws, however, the material is still not quite understandable at the level of the audience. Understanding could be improved through the use of more appropriate supplementary material, simplification of diagrams and figures, or by spending more time explaining each figure. It is apparent that the student has some understanding of the material.

Novice: Essential elements of effective oral communication are not evident. Poor grammar is evident throughout the presentation as shown through poor word choice, sentence structure, and pronunciation problems. No thesis or outline is apparent. Communication aids are not used effectively and are more of a hindrance than a help. The use of a chalkboard, overheads, or other auxiliary material is very awkward. Technically, the report contains numerous scientific errors showing some misunderstanding of the project. The purpose of the research is not evident and is not presented on a level understandable by the audience.

duced versions of posters, seminar summaries, a one-page research summary, final examinations, and examples of instrumental data that students collected would make it a more comprehensive representation of their work. This larger collection would be even more helpful to students seeking employment and to faculty during program review.

As clearly illustrated in the literature, making the portfolio described here into a more reflective document would further encourage student growth and facilitate program assessment. This can be accomplished without making the portfolio overly intrusive of student and faculty time if thoughtful consideration is given to a limited number of prompts for students to respond to each term. Short (one-half to one page) entries asking students to reflect on a summer research experience, a scientific meeting, their career goals, their strengths and weaknesses as scientists, what they hope to get out of their last two years of college, or how their sense of professionalism has grown are only a few examples of prompts that could be added. Having students respond to only one or two prompts each term would go far in extracting greater benefits from the portfolio without adding an onerous time burden.

Summary

The use of portfolios has had a positive impact on students, faculty, and the program in the chemistry department at Berea College. The portfolio allows for the inclusion in the curriculum of activities that occur outside of the classroom and offers a convenient means to monitor student participation in those activities. In addition to guiding students through the curriculum, the portfolio is a document that summarizes their skills, a vehicle through which they can interact with faculty, and a model for professional development. Because tasks outlined in the portfolio are linked to programmatic learning goals, portfolio assessment guides faculty in curricular development. The greatest strength of the portfolio, as it has been implemented, is as a device for program-level assessment that requires *all students* to attain acceptable levels of skill. ■

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