Tiedemann

Enabling All Students to Learn Science

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Using portfolios for instruction

Communicating with students in today's high school science classroom is challenging for teachers because the majority of them speak only English (Darling-Hammond and Sclan 1996). Many of their students, however, do not speak English as their primary language. This creates an instructional barrier across the content areas, and especially in science where much of the learning is abstract and hard to grasp for those who do not speak the language of instruction well.

This created a big challenge for me as I prepared preservice teachers of secondary science in the state of Utah in 2004. In many school districts throughout Utah the percentage of English language learner (ELL) Latino students is around 40% of the total student population (Utah State Office of Education 2004). One way I found to bridge this gap in secondary science and to teach English as a second language is through the use of portfolios.

Communicating through portfolios

Teachers have used portfolios, in one manner or another, for many years. But they are not always used effectively in science. This may be due to teachers seeing portfolio grading as time- and labor-intensive. Many science teachers do not realize, though, that portfolios can be used not only for assessment but also for instruction. Using portfolios for instruction benefits students from many different backgrounds; students are encouraged to reflect and write about their learning experiences as they occur and then have conferences with their teacher regarding concepts that are unclear or misunderstood.

Through the use of portfolios, students learn to use writing to apply inquiry skills and communicate their findings to others. Entries require students to apply what they have learned to their personal lives. As relationships are built in the classroom, students are more comfortable with their learning environment and are empowered to be more successful. The use of portfolios can provide all students an opportunity to gain a greater understanding of concepts and content as they apply their new learning to prior knowledge and cultural experiences.

Throughout this process, students who may be learning English not only have the opportunity to practice writing skills and choose their own words in English to represent their ideas, but they are also empowered to bring in their own

FIGURE 1

Investigation entry.

An investigation entry is typically based on an investigation and is performed in the classroom or at home. Students first come up with the phenomenon to be tested and then state a hypothesis or question to be investigated. The investigation entry is typically presented in the form of a written report, *including tables, graphs,* and/or figures.

The report will contain most of the following information:

- Title
- Purpose
- Hypothesis, question, or problem
- Variables
- Controls
- Procedures
- Materials
- Results (data and observations)
- Conclusions
- References

Students can use the following questions to help plan the investigation:

- What is your question, hypothesis, or problem?
- How will you study your question or hypothesis?
- What kind of answers do you expect to find?
- What steps will you take, and what equipment do you need?
- Which factors will you vary, and which will you control?
- What will you measure, and how will you measure it?
- How many times will you run each test or make each observation?
- How will you communicate your results?

FIGURE 2

SCASS science portfolio scoring guide.

(Reprinted with permission, CCSSO 1996).

Parameter	Level 4
Depth of understanding: How well do you know science? ◆ accuracy ◆ patterns/trends ◆ connection	◆ Scientific information and ideas are accurate, thoughtfully explained, and accurately linked to major scientific themes or unifying concepts. ◆ Patterns and trends are identified, discussed, and extended through interpolation or extrapolation. ◆ Scientific connections are correctly identified and discussed.
Evidence of inquiry: What can you do in science? ◆ scientific questioning ◆ evidence/explanation ◆ methods/data ◆ analysis/conclusions ◆ future steps	◆ Questions are clearly identified and formulated in a manner that can be researched. ◆ Evidence and explanations have a clear and logical relationship. ◆ Methods generate valid data to address or resolve questions. Where appropriate, variables and controls are specified. ◆ Analyses are accurate. Conclusions are valid, detailed, and consistent with data. ◆ Future steps are proposed and linked to previous steps.
Communication: How well do you communicate what you know and can do in science? ◆ clarity ◆ focus/organization ◆ medium	◆ Scientific information is communicated clearly and precisely, but may also include inventive/expressive dimensions. ◆ Presentation is effectively focused and organized. ◆ A variety of media enhance communication.
Relevance to society: How well do you show how science affects people's lives? ◆ person and society ◆ context ◆ consequences/alternatives ◆ connections	◆ Relevant applications to personal and societal issues are identified and insightfully described. ◆ Background information provides clear context for interpretation. ◆ Consequences and alternatives are identified and discussed. ◆ Multiple relevant connections are made to other content.

experiences and make the science content culturally relevant to them. Portfolio use transitions the learning environment from being teacher-centered to student-driven and provides more opportunities for students to develop their own meanings and to have choices in their learning experiences.

Three easy pieces

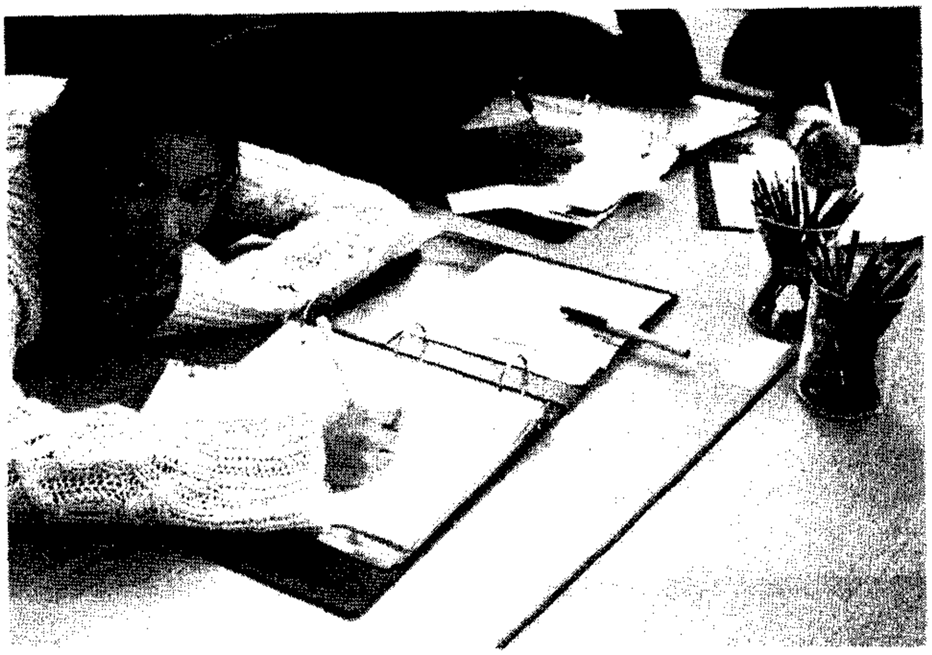
When I taught secondary science in 2001 in Ohio, the instructional model of portfolio use I implemented was one I adapted from the State Collaborative on Assessment and Student Standards (SCASS) science portfolio curriculum (CCSSO 1996). This model contains three types of portfolio pieces; the use of inquiry and the National Science Education Standards (NRC 1996) are a critical component of each entry. This replaced lab reports for entry-level science classes that I taught.

Investigation

The first type of portfolio piece is the investigation entry (Figure 1). This entry is based on a scientific investigation guided by the teacher, but mostly constructed and performed by the student. The student writes the entry throughout the investigation in place of a typical lab report, with input and assistance as needed from the classroom teacher and peer group.

An example of this type of work has a teacher posing to students a problem called "Hot Wheels Madness." Students develop an investigation to determine the effect of ramp height and car type on the average speed and distance traveled by a toy car. Students

Level 3	Level 2	Level 1
• Scientific information and ideas are accurate and linked to major scientific themes or concepts. • Patterns and/or trends are identified. • Scientific connections are identified.	• Scientific information has occasional inaccuracies or is simplified. • Patterns or trends are suggested or implied. • Scientific connections may be implied.	• Scientific information has major inaccuracies or is overly simplified. • Patterns and trends are unclear or inaccurate. • Scientific connections are unclear or absent.
• Questions are clearly identified. • Evidence and explanations have a logical relationship. • Methods generate valid data related to the question. Where appropriate, variables and controls can be identified by the reader. • Analyses are accurate, conclusions are valid and consistent with data. • Future steps are proposed.	• Questions are implied. • Evidence and explanations have an implied relationship. • Methods generate data related to the question. • Analyses are mostly accurate, conclusions are related to data. • Future steps may be implied.	• Questions are unclear or absent. • Evidence and explanations have no relationship. • Analyses are unclear or inaccurate, conclusions are unclear or unrelated to the data. • Future steps are unclear or absent.
• Scientific information is communicated clearly. • Presentation is focused and organized. • Medium facilitates communication.	• Scientific information has some clarity. • Presentation has some focus and organization. • Medium permits communication.	• Scientific information is unclear. • Presentation lacks focus and organization. • Medium hinders communication.
• Applications to personal and societal issues are identified. • Background information provides context for interpretation. • Consequences and alternatives are identified. • Connections are made to other content areas.	• Applications to personal and societal issues are suggested or implied. • Background information provides some context for interpretation. • Consequences and/or alternatives are implied. • Some limited connection is made to other content areas.	• Applications are unclear or absent. • Background information provides minimal context for interpretation. • Consequences and alternatives are unclear or absent. • Connections are not made to other content areas.



research the student makes a decision regarding the issue. The student must identify and cite proper sources, analyze and synthesize information, and entertain alternative solutions to the problem. The teacher should ask students to come up with a problem that is important for them to investigate and approve their choices to ensure that they have a problem for which they can find data and work toward solutions. Students often choose to investigate local environmental issues or other topics that are of interest to them, and my students said they enjoyed feeling like they were "making a difference" in their own communities by solving problems that were relevant to them.

Again, the teacher guides students through this process and provides needed assistance along the way, whether it is grammatical or concept-oriented. Students continuously write about what they have learned, and potential problems are pointed out by the teacher; this immediate feedback contributes to student success. The portfolio gives a record of student progress as well as a finished report.

The key to using portfolios for instruction is that students have great latitude in choosing what they want to do and what is of interest to them.

then work with a partner to design an experiment and test out their toy cars. In their portfolio entry, students use their own words to describe their procedures, experiment, and results. My students enjoyed having the freedom to design their own experiments and learned a lot through trial and error.

The activity and portfolio entry provide an excellent way for science teachers to formally assess whether students understand the concepts and processes throughout the learning process instead of waiting until the end of a chapter or experiment to find out whether students have learned the concept. Questioning students throughout the investigation—as they are writing and working through their own thought processes—allows teachers to guide student learning as needed. Using portfolios for instruction provides an opportunity for ELL students to express their learning through their own style of writing, which is much less threatening than a typical standardized unit test or other form of traditional assessment.

Research piece

The second type of entry is a research piece. This entry requires students to conduct authentic research. The research is meant to solve a problem, and at the end of the

Application

Application is the focus of the third type of portfolio entry. This entry requires students to apply scientific information they have learned to another situation in their own lives, and the format of the entry can be either expressive or inventive in nature. Students may use the expressive format in communicating information to others in a medium such as a letter, newsletter, or other written product. Many students feel empowered by "having a voice" when writing to local community leaders or state representatives about applying a solution to a community problem, such as pollution. An inventive format that students may use might include inventing a device or constructing a model.

The key to using portfolios for instruction is that students have great latitude in choosing what they want to do and what is of interest to them. The application entry includes a written component to accompany the model the student constructs, and it may include digital photographs of the model.

For teachers who prefer to provide a structured activity for this application entry step, a big year-end project that I used for several years was a roller coaster model problem-based learning activity. Students are told that a local theme park is asking students to create working marble roller coaster models that are going to be considered for construction of a new full-sized attraction for the upcoming year. Student groups are given very little guidance—other than basic specifications—and hit the ground running, applying what they learned in their physics unit to create a working roller coaster model with loops and corkscrews. They work in teams of three or four students to come up with a total package, including the following:

- research on steel versus wooden coasters,
- a proposal with research and data collected that justifies the coaster design including all applicable scientific principles,
- a small-scale blueprint of the rollercoaster denoting landscape and intricate details of the coaster specifications,
- a small-scale model marble coaster that demonstrates many or all of the components of the full-size coaster,
- a materials list of the small-scale coaster,
- an application portfolio entry of all daily work and data collected (and applicable principles) contributing to the design and final product,
- and a videotaped presentation of the coaster for the committee to view.

All three of the above portfolio pieces are used as instructional tools to reach all students, regardless of their cultural background or native language. The student first writes a draft, which is evaluated by the teacher during the student conference, to address any misunderstandings, writing issues, or other content- or concept-related problems. The student then refines his or her work and creates a final draft for the teacher to review. The teacher determines how much class time is spent on portfolio pieces.

I had students begin sketching out their piece as they were actively engaged in the investigation, research, or application activity. I also scheduled conferences with students to discuss their work while the rest of the group was involved with other activities. However, students did some of the work and revisions independently. The amount of class time spent on portfolio pieces was roughly equivalent to the time I had spent in previous classes on lab reports and other worksheets that went along with experiments and investigations. The main difference was that students chose how to structure their responses, the responses were in their own words, and the responses were open-ended and not one-word or -sentence responses to review questions.

Evaluation portfolios

There are a variety of ways that portfolio pieces can be evaluated. For instance, I used to have students create a showcase folder, into which they placed all portfolio pieces throughout the semester or year. Part of their overall term grade was derived from the portfolio pieces they selected. There was an opportunity for students to compile eight to ten entries per semester, and I asked students to choose the best three entries, which are evaluated for key components using the SCASS rubric (CCSSO 1996) found in Figure 2, pp. 34–35. Students could choose which investigation, research, and application entry to include in their final folder (one from each area); this allowed students to best represent their work for the year. Alternatively, a portfolio can include representative work from throughout the year and thus give a record of student progress over time.

Criteria for evaluating individual portfolio pieces are based on the students' depth of understanding of the concept or content, evidence of the use of inquiry in their investigation or research, how effectively students communicated what they have learned, and how well a student related what was learned to his or her own culture and society. These criteria are detailed in the SCASS rubric (CCSSO 1996).

Teachers must understand and appreciate students' cultural and ethnic backgrounds in order to form relationships and to help students learn. I have found that using portfolios, not only for assessment, but most importantly for instruction, has empowered my ELL students and has enabled them to take what they have learned in the science class and apply pieces of their own lives, cultural interests, and backgrounds to their work. It has been a great experience for students from all backgrounds in the class, as the whole group learns through discussion of the diversity of approaches used. Students pick one portfolio entry to share with the class through a science share-a-thon at the end of the semester. This provides more meaning, for all students, to what is learned in science and an opportunity to develop a better understanding and more detailed learning of science than was possible with traditional approaches to teaching science. ■

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