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Physics Portfolios: A picture of student understanding

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PHYSICS PORTFOLIOS

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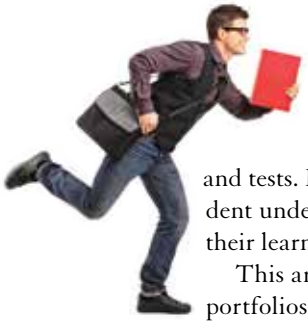

Traditionally, teachers assess students' physics understanding through lab activities, responses to open-ended word problems, and tests. But there's another way to measure student understanding, one in which students apply their learning to the world around them.

This article shows how to implement student portfolios, which allow students to set goals they can monitor throughout the year and actively participate in assessment. When students build portfolios, they can evaluate and reflect on their own work, promoting engagement with the course and content (Danielson and Abrutyn 1997), and teachers can better assess students' goal movement and see growth in students' conceptual understanding.

Portfolio assessment is a powerful motivator because students get to make choices (Tomlinson 1999), personalize learning goals, choose the assignments they want to include, and focus on areas of interest. Portfolios provide insight into students as individuals, revealing alternative conceptions and incomplete understandings (Danielson and Abrutyn 1997). Teachers can differentiate how students convey understanding based on readiness, interest, or learning profiles (Tomlinson 1999) and have opportunities to communicate with parents about student work (Nickleson 2004).

The first author has implemented a physics portfolio project in two different general-level high school physics courses over the past six years. Students provide pictures of their understandings and make real-world connections as they learn, addressing the *Next Generation Science Standards (NGSS)* (Achieve Inc. 2013) and *Common Core State Standards (CCSS)* (NGAC and CCSSO 2010). Students reflect on their studies and goals for the course and provide evidence of their learning throughout the year, allowing the teacher to formatively assess both student progress and the course itself.

Course description

Each quarter, the teacher assigns cooperative groups of three or four students based on learning profile, student interest, and readiness. Students work together on labs and projects and support one another as they work through problem-sets and labs. On the first day of class, the teacher provides students with a course syllabus, a description of the portfolio and its components, and the following objectives for the portfolio:

- accurately communicate scientific concepts related to physics,
- develop a broad understanding of proficiencies in the course,
- assess and reflect upon course learning, and
- explain the relevance of physics studies in today's world.

The teacher reiterates these objectives throughout students' completion of the project and uses them in the final portfolio assessment.

Portfolio components

Students' portfolios comprise a series of homework assignments that consist of a title page; table of contents; a letter and picture of introduction; essays, pictures, and study guides for each unit; self-evaluation and learning evidence from each quarter; project components; and a final reflective essay (Figure 1, p. 40). Students work on these assignments for grading throughout the year, collecting them in a binder graded at the end of the year with the weight of one or two test grades.

Letter and introductory photograph

Students' first portfolio assignment is to write a letter and take an introductory photograph representing who they are as individuals. The photo could be of something representing their character, such as a picture of their favorite things or their favorite place to go, or of themselves. The letter includes information about the student, his or her progress in science courses, a list of the math courses he or she has taken, and his or her course goals. These letters are incredibly informative, helping the teacher learn contextual information about students' learning preferences. Students edit the essay and resubmit it with the final portfolio.

Essays and pictures

Students submit essays and pictures at the end of each unit of study. They photograph real-life examples of the unit's physics concepts and explain how the pictures represent the concepts in a one- to three-paragraph essay for each photo. For example, at the end of a unit on projectiles, one student photographed the parabolic path of water shooting from a drinking fountain; for a unit on waves and light, a student who plays piano photographed piano keys and discussed in his essay how light reflects off smooth, shiny surfaces (Figure 2, p. 42). Students should incorporate their own interests into this part of the portfolio and can self-differentiate based on their interests. For example, students can use the same person or object in all 12 pictures; tell stories with their essays; use photos from sports, dance, or art works; or incorporate their favorite things into the pictures. It's important that students take the photos themselves, giving the teacher insight into their thinking, rather than gathering the photos off the internet.

FIGURE 1

Components of the physics portfolio project.

Component	Completion time frame	Description	How and when assessed
Title page	Final submission	• Includes student name, title, and year • Is pleasing to the eye and should invite the reader to continue	Teacher assesses final submission using Final Submission Rubric (see "On the web").
Table of contents	Final submission	• Accurately shows where everything in the portfolio is located	Teacher assesses final submission using Final Submission Rubric.
Introduction letter and picture	Beginning of the school year and final portfolio	• Spans at least one page • Includes information about the student and his or her goals and progress in science courses and current math courses • Represents the student as an individual	Teacher assesses the initial letter and picture as a homework grade. Teacher assesses the edited version at final submission.
Unit pictures and essays	The day after each unit test and final portfolio	Essays • Span at least one paragraph • Include a title • Explain the physics in the picture Pictures • Include titles • Are laid out in a creative, appealing manner	Teacher assesses the initial pictures and essays as a homework grade. Teacher assesses the edited versions at final submission.
Unit study guides	The day of each unit test	• Summarize the main points of each unit • Help students prepare for each test	Teacher assesses study guides as homework grades.
Self-evaluation and evidence of learning	Once a quarter and with final portfolio	• Provides evidence of self-assessment, self-reflection, and relevance of the students' physics studies	Teacher assesses this assignment as a homework grade. Teacher assesses the edited version at final submission.
Project components	Final submission	• Included in the portfolio	Teacher assesses this assignment as a homework grade.
Final reflective essay	Final submission	• Includes all prior submissions	Teacher assesses at final submission, using Final Submission Rubric.

Students prepare study guides for each unit. Students record important formulas, key ideas, labs, and lab objectives and then use these guides to help them study for unit exams and the final exam.

Students' essays and pictures illuminate whether they have developed appropriate understandings of the topic. Teachers can detect whether students retain alternate conceptions after instruction and address this through feedback and discussion, emphasizing that students should refer back to unit objectives and essential questions as they take pictures and write essays. This helps students evaluate whether they have accomplished the goals of the unit. After submitting the picture and essay for each unit, students receive feedback from the teacher and revise their essays. Students include their edited essays in their final portfolio submissions.

Study guides

Study guides that students prepare for each unit are due the day of the test and are a form of review. Students record important formulas from the unit, key ideas, labs, and lab objectives and use these guides to help them study for the unit exams and then for the final exam. Teachers can differentiate study guides based on student readiness, providing more advanced students with study guides with general categories to complete on their own and less advanced students with more structure for their study guides. The teacher grades the study guides as a homework assignment, and students include them in their final portfolios without further editing.

Self-evaluation and learning evidence

Once a quarter, students choose a lab that demonstrates their progress toward learning key ideas in the physics course. Students write an essay, answering the following questions about the lab:

- What did you do well?
- What do you need to improve?
- Are some of the details escaping you? Explain.
- Did the evidence show what you knew? Elaborate.
- Did you lose points for things that you thought you understood? Explain.
- What, if anything, would you do differently next time? Explain.
- How do the preparation and completion of this lab relate to your other courses? How do they relate to your personal life? Elaborate.
- Did you accomplish your goals for the quarter? Explain. What are your goals for next quarter?

This part of the portfolio allows students to reflect on their learning and evaluate their understanding of the course concepts. The teacher also gains insight into student's progress, grading the essay as a homework assignment. Students edit their essays and include them in their final portfolio submissions.

Project components

Each quarter, students complete a project for their physics portfolios. For the first quarter, students film a review video and turn in the video's script. For the second quarter's project, students use limited materials to design a model car that will travel four meters as quickly as possible. They submit their design logs, and the teacher grades them for content and accuracy, returning them for inclusion in students' portfolios. The goal is for students to represent every major part of the course in their portfolios.

Final reflective essay

In students' final reflective essays, they address the following:

- Describe your most valuable learning this year.
- How do you know you learned physics?
- What did you enjoy learning the most?
- How did this course impact your life?
- What advice would you give someone who will take this course next year?

This essay is a cumulative analysis of students' experience in the physics course and is invaluable, providing the teacher ideas on how to modify the course or various assignments, insight into what students found most valuable, and a roadmap of students' longitudinal physics understanding. Students

FIGURE 2

Examples of student portfolio pictures and content.

Student portfolio pictures	Objectives
	• Define acceleration, including its vector nature, and instantaneous velocity • Distinguish between instantaneous velocity and average velocity • Determine if velocity is constant or changing
	• State and give examples of Isaac Newton's first law of motion • Draw a force diagram for an object • Resolve the forces acting on an object into *x* and *y* components and find the resultant vector of forces
	• Describe the horizontal and vertical motion of an object • Draw a motion map for an object undergoing parabolic motion, including velocity and acceleration for both dimensions • Explain the effect that a projectile's mass has on its time of flight
	• Distinguish between centripetal and centrifugal force • Graph and state the relationships between velocity and mass, velocity and radius, and velocity and period for an object undergoing uniform circular motion

submit this component with the final portfolio, and teachers grade it as part of the final submission.

Final portfolio assessment

The teacher grades the portfolio's components throughout the year to provide students with formative feedback. At the end of the course, the teacher assesses students as they participate in the Portfolio Gallery Hop, give a formal presentation of their portfolios, and turn in their final portfolio binders. (Note: A rubric is available online; see "On the web").

For the Portfolio Gallery Hop, students bring a comment sheet and their completed portfolios to class. Students then place the comment sheet in the front of their portfolios and rotate around the classroom, viewing their classmates' portfolios, rating them, and writing signed comments on each comment sheet. Students are able to share their pictures and

learning with their peers and support and encourage one another through their comments. The teacher encourages students to write constructive comments by holding them accountable through their signatures.

Students' parents also complete a comment sheet, providing insight into what students have been doing throughout the year and encouraging positive feedback. If parents aren't available, the student can share his or her portfolio with another teacher, an older relative, or a legal guardian. Students include all comment sheets in their final portfolio binders.

Students also select five pieces from their portfolios to discuss with the class in a three- to five-minute slideshow presentation, with extra time for peer comments and questions.

The project culminates in the actual portfolio binder. Students complete the final submission rubric (see "On the web") and submit it along with their portfolios for grading. The rubric allows students to reflect on anything they may have forgotten to submit as part of their portfolios. Ideally, the teacher confers individually with each student after grading the portfolio, giving direct feedback and allowing the student to ask questions about his or her grade.

Issues to consider

Because students will collect and revise work throughout the school year, they will need a tracking system. Teachers should make clear any grade implications if students lose pieces of the portfolio. How will students take, print, and submit photos? With their own cameras or ones provided by the school? May they use a cell phone camera? Will students print the photos or will the teacher print them after electronic submission?

How much time will grading take? By assigning the components of the portfolio as homework assignments throughout the year, teachers can minimize grading time for the final portfolio. Students can also periodically use five to 10 minutes of class time to check progress and note updates they need to make. Teachers may choose to omit some portfolio components to reduce the time required.

Some teachers may find electronic portfolios to be easier to grade and return than the binder version described in this article. Students can use Prezi, Glogster, or some other electronic method (see "On the web") to create and submit portfolios—as long as they have internet access at home or at school.

Conclusion

The project described here is just one way to implement portfolios in a high school physics course, and teachers can easily modify this project to fit the needs of other courses, limited only by their imagination and available time.

A portfolio requires students to become active participants in their learning as students, parents, and teachers watch this growth throughout the year. Portfolios can

- highlight students' depth of understanding;
- reveal students' alternative conceptions;
- provide opportunities for teachers to differentiate based on student interest, learning profile, and readiness;
- encourage teachers to improve areas of their courses;
- offer insight into students as individuals; and
- arm teachers with more information about their classrooms.

These assessments can provide a true picture of student understanding. ■

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On the web

Final Submission Rubric: *www.nsta.org/highschool/connections.aspx*
Glogster: *www.glogster.com*
Prezi: *http://prezi.com*

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