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Using Portfolios in a Flipped Dynamics Class for Homework Documentation and Pre-Class Work Accountability

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Abstract

In the Spring 2024 and Fall 2024 semesters, students at the United States Air Force Academy (USAFA) were required to create portfolios of their work in a flipped sophomore level Dynamics course. The decision to require portfolios was driven by three primary objectives: 1) to help students organize their coursework and recognize the value of such organization, 2) to ensure accountability, specifically by verifying that students completed the handouts associated with the course videos, and 3) to evaluate the neatness and documentation of handwritten homework. The last objective was necessary because in the Spring of 2024 we used McGraw-Hill Connect for the homework. When using Connect students are typically asked to put numerical answers into this system, but their process is not checked. Based on student feedback regarding the portfolio in the Spring of 2024, we decided to retain this requirement in the Fall of 2024 even though we decided not to use Connect. In this paper we will discuss 1) the structure of our flipped classroom, 2) the details of the portfolio assignment, and 3) student feedback on the portfolio assignment. In general, the assignment was rated positively by students, with over 55% indicating that it was a good use of their time, over 70% indicating that it motivated them to watch the videos, and over 80% indicating that it facilitated organizing their course work.

Introduction

Portfolios have long been recognized as a valuable tool for assessing student growth, fostering reflection, and demonstrating competencies across a wide range of disciplines. In fields such as fine arts, writing, and teacher education, portfolios are used to showcase a curated selection of work that illustrates a learner's progress, creativity, and mastery of essential skills. In these contexts, portfolios encourage students to critically evaluate their achievements and articulate their learning processes, promoting both self-awareness and a deeper engagement with the subject matter [1-2]. These benefits have increasingly drawn the attention of educators in technical disciplines, including engineering, where traditional assessment methods often focus heavily on quantitative metrics such as exams and problem sets.

In engineering education, portfolios have been employed to assess a variety of skills and outcomes that are not easily captured through conventional means. For example, portfolios are used to evaluate students' design capabilities, teamwork experiences, and communication skills, core competencies emphasized in ABET accreditation criteria [3]. Portfolios provide a structured platform for students to document their iterative design processes, reflect on their decision-making, and align their learning artifacts with specific course or program outcomes [4]. Furthermore, the reflective component of portfolios has been shown to foster metacognition, helping students identify areas for improvement and connect their coursework to broader professional contexts [5-6].

In this paper, we will discuss the integration of portfolios into a flipped sophomore-level Dynamics course, an application where their use has been relatively unexplored. Flipping Dynamics, with its emphasis on analytical problem-solving and applied mathematics, presents

unique challenges and opportunities for portfolio-based learning. We chose to require portfolios for several practical reasons. First, we wanted to motivate students to watch the pre-class videos by requiring them to include completed notetakers in their portfolios. Second, we aimed to review their homework solution write-ups to ensure they were using a logical problem solving process. Finally, we sought to provide students with an organized collection of course materials as a model for how they could organize information in future engineering courses.

Description of our flipped Dynamics class

At USAFA, we have been teaching Dynamics in a flipped format for several years [7]. Our courses typically have between 15 and 25 students per section and there are usually two or three sections each semester. In this class structure, technical content for each lesson was delivered via pre-recorded videos, and the in-class activities were designed to be a time for active engagement of students in applying the material. A detailed description of the structure of our course is provided below.

Pre-class activities

Typically, three videos were provided per lesson: one covering the technical content and two example problems. The videos were usually 7 to 10 minutes long, but some of the example problem videos were as long as 15 minutes, The total running time for all three videos was usually between 20 and 30 minutes, so we emphasized to students that we would give them at least 30 minutes in class to work on the next homework assignment. One of the reasons we did this was to combat the perception that flipped classes are more work since students are required to watch the videos outside of class.

Students were required to complete a "notetaker" – basically a handout – while watching the videos. The notetaker had the dual purpose of trying to keep students engaged while watching the videos and of ensuring that they had a neat set of notes. Finally, there was a pre-class quiz that was administered in Blackboard. This pre-class quiz often contained several multiple-choice questions, but it always asked students if they had any questions on the videos. For the flipped format to be effective, it is essential that students complete the pre-class work to prepare for in-class active learning.

In-class activities

The in-class activities typically started with a brief quiz over the material covered in the videos. The quiz was often started individually, but after about 5 minutes, students were allowed to work with the people around them. They were called quizzes, but they were actually active learning exercises. They were not collected but were briefly reviewed to ensure that everybody had completed them correctly.

Following the quiz, the instructor of each class presented a very quick summary of the key ideas from the videos via a single PowerPoint slide. Finally, the remainder of the class, typically at least 30 minutes, was used for “boardwork,” that is, students were asked to get out of their chairs and work on the whiteboards in groups of two or three students. The groups were changed

randomly throughout the semester, and students were instructed to neatly set up the homework problems and to make sure everybody in their group understood their solution.

Homework and the portfolio assignment

Since our classes at USAFA are small, students had historically scanned their notetakers, and they were provided with worked-out solutions and asked to grade their own homework and submit an electronic version of their graded homework to Blackboard. These files were then quickly glanced over by the instructor, looking for completeness, correct diagrams, and clear documentation of their solutions. The grades were then recorded in Blackboard. For our small classes, the time required to look at all the files was not prohibitive, and it offered each instructor insight into student comprehension of the homework.

In the Spring of 2024, we used McGraw-Hill Connect for homework assignments for the first time. Because of this, we also decided to require students to keep a portfolio. The McGraw-Hill Connect homework system is an online educational platform designed to support student learning and engagement through adaptive technology. It provides instructors with tools to create and assign homework, quizzes, and practice problems tailored to course content. Each student is given a unique set of numbers for each homework problem, and Connect offers immediate feedback, detailed explanations, and the ability to release solutions after submission. It is ideal for assigning homework in large classes where the manual grading of homework is burdensome.

However, systems such as McGraw-Hill's Connect or Prentice-Hall's Mastering Engineering have drawbacks since students typically only submit numerical answers, leaving their work unchecked for neatness, accuracy, or clarity. As engineering instructors, we recognize that the problem-solving process in these courses is more important than the final answer.

For this reason, we decided to require students to create a portfolio of their clearly documented homework solutions, their in-class quizzes, and their notetakers. For the homework, students input their answer into Connect and received immediate feedback, but they were also required to write-up their homework in a neat and organized fashion and place it in their portfolio, which was turned in 4 times during the semester. The primary criteria for grading the portfolios were 1) neatness, 2) completeness, and 3) organization.

Requiring portfolios provided accountability for students watching the videos, since their notetakers were included. We were also able to emphasize the importance of technical communications by requiring students to have neat, organized, and appropriately documented homework solutions in their portfolios. The handout we gave students for the portfolio is shown in the Appendix.

Based on student feedback from the Spring of 2024 which we will discuss in the next section, we decided to modify the course slightly for the Fall of 2024. We decided not to use McGraw-Hill Connect because of the feedback we received in the Spring. Since the class was flipped, at least 30 minutes of class time was devoted to students working on homework. Student groups usually completed one problem and almost finished the second problem. The numbers used in the homework problems that were started on the whiteboards were those from the textbook. When

the students used Connect, however, they were all given unique numbers that were different than the numbers in the textbook. This made some students feel like they had to solve each homework problem three times – once on the whiteboards, once when they solved the Connect problem, and a third time when they had to write up the problem for their portfolio. We tried to address this by encouraging them to just set up the problems in class on the whiteboards and then to substitute numbers into the equations outside of class, but this did not always occur.

Results

Near the end of the semester, students were required to complete a portfolio reflection assignment. This assignment consisted of five Lickert scale questions where the answers ranged from "strongly agree" to "strongly disagree." The questions and the results for the Spring and Fall of 2024 are shown in Table 1. Recall that in the Spring of 2024 we used Connect for the homework and in the Fall of 2024 we did not. From Table 1, it is clear that over 80% of students agreed or strongly agreed that the portfolio helped them keep material organized. Based on the comments, some students who disagreed said that they already kept their material organized, so this assignment did not help them. The results also show that the portfolio provided motivation for most students to watch the videos, as indicated by the 73.9% and 77.8% who agreed or strongly agreed with this statement. There was a significant difference in whether or not students believed that the portfolio helped them improve their communication skills between the two semesters, with 87% agreeing or strongly agreeing in the Fall of 2024 and only 50% in the Spring of 2024. The reason for this difference is still unclear. Most encouraging in these results, and one of the reasons we decided to keep this assignment in the Fall of 2024 even though we decided not to continue using Connect, was the fact that over 50% indicated that they considered this activity a good use of their time and planned to keep a portfolio in their other courses.

Table 1 – Results from the portfolio reflection assignment

Question	Strongly agree/ agree		Neutral		Disagree/ strongly disagree	
	Spring 24	Fall 24	Spring 24	Fall 24	Spring 24	Fall 24
The portfolio helped me keep the course material organized.	80.6	87.0	11.1	13.0	8.3	0.0
Knowing I needed to put the notetakers in the portfolio motivated me to watch the pre-class videos and complete the notetaker.	77.8	73.9	8.3	17.4	13.9	8.7
Writing up the homework for the portfolio improved my engineering communication skills.	50.0	87.0	36.1	8.7	13.9	4.3
Keeping a portfolio for the course was a good use of my time.	63.9	56.5	13.9	39.1	22.2	4.3
Based on my experience in this course, I plan on keeping a portfolio of course material (homework, notes, etc.) in future engineering courses.	52.8	52.2	25.0	26.1	22.2	21.7

In addition to the Lickert scale questions, there was a multiple-choice question asking about their approach for adding material to their portfolios. The results from this question are shown in Table 2. In the Fall 2024 semester there was a significant drop in the percentage of students who indicated they added material as the course progressed. We believe this is because a larger number of students are using tablets each semester for notetaking and completing homework, so they keep all their course materials electronically. The in-class quizzes were hard copies, so they needed to scan these into their tablets for inclusion in their portfolios. For the portfolio submission, we asked students to submit a single pdf or a three-ring binder with all of the required materials. In hindsight this created more work for students who used a tablet and was only done at the last minute.

Table 2 – Answers to the question, "What was your approach when adding material to the portfolio?"

Answers	**Spring 24**	**Fall 24**
I did not keep a portfolio for this class.	0%	0%
I added material to the portfolio as the course progressed so turning it in was no additional work.	88.9%	65.2%
I did not think about the portfolio until it was due, so I added and organized the material the day or two before it was due.	11.2%	34.8%

There were several free response questions in the portfolio reflection assignment. In this section we summarize the results from the questions asking students what they would change about this portfolio assignment and what they would keep the same. These questions and a summary of the key themes emerging from students' answers are shown below:

Question: "What would you change if you had a chance to do this portfolio again?"

Summary of responses from both semesters:

1. Flexibility in Format:
    - Students in both semesters requested options beyond the standard portfolio format. Suggestions included allowing digital note submissions, photos of boardwork, or alternative formats based on personalized organization methods.
    - Students emphasized the need to accommodate different learning and note-taking styles.
2. Frequency of Checks:

- A common recommendation was to increase the frequency of portfolio checks. Many suggested smaller, more frequent submissions to improve accountability and to reduce the burden before submission deadlines.

3. Submission Logistics:
   - Students using digital tools found compiling and submitting a single PDF cumbersome. Suggestions included in-class checks or alternatives to full submissions for digital notes.
4. Relevance and Utility:
   - Several students felt the portfolios sometimes involved redundant tasks (e.g., rewriting boardwork) and requested more targeted conceptual questions or fewer example problems.
5. Integration of Additional Materials:
   - Students proposed including quizzes, simulations, or Blackboard pre-quizzes in the portfolio to enhance its utility as a study tool.

Question: "What would you keep the same about the portfolio assignment and why?"

Summary of responses:

1. Accountability and Organization:
   - Students from both semesters valued the portfolio's ability to keep them organized and accountable. They appreciated having all course materials centralized and accessible for studying.
2. Structure and Deadlines:
   - Many liked the structure of organizing materials by lesson and found the deadlines (before each exam) helpful for preparation.
3. Integration of Materials:
   - The inclusion of lecture notes, homework, quizzes, and MATLAB code was consistently praised as beneficial for studying and maintaining course engagement.
4. Motivation to Stay on Track:
   - Students appreciated that the portfolio requirement encouraged them to watch videos and complete notetakers, especially in the flipped classroom format.

Students in both semesters emphasized the importance of flexibility, frequency of checks, and logistical simplicity for digital submissions. They valued the portfolio's role in organization, preparation for GRs, and maintaining accountability. The integration of varied materials (notes,

quizzes, and homework) was universally appreciated. There were also some differences between the two semesters. In the Spring of 2024, students' comments more explicitly emphasized the portfolio as a tool for staying on top of their work, with suggestions leaning towards increasing submission frequency to help manage their workload. In the Fall of 2024 student comments, more students focused on the utility of the portfolio for conceptual understanding, suggesting integrating Blackboard pre-quizzes and including simulations. They also expressed greater concern about the portfolio's workload and suggested reducing the rigidity of grading.

Conclusion

The integration of portfolios into a flipped Dynamics classroom demonstrated clear benefits in enhancing organization, accountability, and communication skills among students. Over the two semesters of implementation, feedback highlighted the portfolio's value as a tool for keeping course materials organized, encouraging pre-class preparation, and improving the documentation of problem-solving processes. We found benefits in the portfolio assignment whether or not we used McGraw-Hill Connect for assigning and grading the homework.

Notably, the portfolio's effectiveness in motivating students to engage with pre-class videos and maintain comprehensive notes underscores its utility in supporting the flipped classroom model. The observed improvement in communication skills, particularly in the Fall 2024 semester, suggests that iterative refinement of the assignment can enhance its impact. At the same time, challenges such as submission logistics, workload perception, and flexibility of format remain areas for improvement.

Future iterations of the portfolio assignment could address these concerns by offering greater flexibility in submission formats, especially for students who use a tablet for taking notes and doing homework. This adjustment will ensure the portfolio continues to be an effective tool for achieving course objectives while accommodating a broader range of student needs.

Overall, the portfolio assignment has proven to be a valuable addition to our flipped Dynamics course, equipping students with skills that extend beyond the classroom. By refining its implementation based on student feedback, this approach has the potential to serve as a model for other technical courses aiming to improve accountability, engagement, and skill development in a flipped classroom environment.

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Appendix A – Portfolio Assignment

Dynamics Portfolio Assignment

Artists often create portfolios to demonstrate their work and highlight the skills they have developed. We are adapting this model so that you can demonstrate your learning in Dynamics. If it proves useful, you can then follow this model in future courses. By creating a portfolio for this class, you will have an organized set of course materials that will be useful not only during this class, but also after you leave USAFA.

Logistics

- The portfolio will be collected four times during the semester so we can provide feedback to you on your work. You should keep up with your portfolio, and not try to simply fill in everything right before it is due.
- It will be worth 5% of your final grade.
- We will not be rechecking all of your homework and quiz solutions, but rather, we will be looking for completeness, neatness, and a clear organizational structure. For example, for the homework we will be checking to make sure you are drawing good diagrams when appropriate.

Requirements

Your portfolio can be either hard copy (e.g., three ring binder) or in digital form (which you will need to be able to export as an organized PDF). You should arrange this by lesson, and each lesson should contain the following:

1. A filled out notetaker that demonstrates you have watched the pre-class videos and taken notes while doing so.
2. Notes you take during class.
3. Any in-class quizzes or handouts.
4. Homework problems written out in a neat, legible format. A sample homework solution is shown on the next few pages of this document. A photo of the boardwork is not acceptable since the boardwork is done in groups and we want you to demonstrate individual proficiency. Your

homework solutions should be written up using the following guidelines (improving your professional communication skills is one of the objectives of this class):

   a. Each problem needs to be started on a new page.
   b. Only write on one side of the paper.
   c. Clear documentation of your solution with enough text such that somebody else can understand your solution.
   d. If diagrams such as free-body diagrams and kinetic diagrams or impulse-momentum diagrams are required, they should be complete and neatly drawn.
   e. Box your final answer.
   f. If you use Matlab to solve equations, you should include a copy of your Matlab code.

5. Any reflections, questions, or thoughts you have about the lesson.

Other comments on the homework

The handwritten problems are to help you get in the habit of communicating like an engineer. You will be submitting your homework over the online Connect system, but it is still critical that you develop the skills of sketching, drawing appropriate diagrams, following a well-thought-out solution process, and writing out easy-to-follow solutions to problems. You will enter different numerical answers into Connect and will have multiple attempts to get the correct answer. After you submit your answers, you will get access to a full solution. This immediate feedback will help you learn the material and come to class the next day prepared for the upcoming dynamics principles. Having your written out solutions in the portfolio will also help you study for quizzes, GRs, and the final exam.