Measuring the Effectiveness of Videos for Concept Understanding in a Flipped Engineering Class

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Abstract:

Flipped classrooms with different forms of implementation are now popular in engineering programs. Instructors use the flipped model to focus on learning activities in the classroom, application of theoretical concepts, and students have to gain understanding on the concepts from videos or other instructional material prior to class. Thus far, the research on this pedagogy focused largely on students' perspective of this type of classroom and inquiry has been done on its effectiveness over the traditional lecture. The purpose of this study is to gauge students' understanding of the concepts presented in the video they are supposed to watch prior to class. Students enrolled in three sections of "Introduction to Fluid Mechanics" participated in this study. To test the impact of review before quizzes on student performance, a quasi-experimental study with three conditions for test-taking was used: a) with brief review of notes before the quiz b) with brief reflection on videos before the quiz c) no review/reflection before quiz. In each condition, students took a three-minute, one-word quiz. By being provided only one word as a prompt, student learning is aided because students are required to recall, rather than identify, pertinent information through identification of the context of the word and explain the concept in their own words.

Introduction:

Passive students during lectures retain less, while active students perform better [1]. In recent years flipped classrooms have become, to some degree, popular environments for teaching across disciplines, though the investigations in assessing their effectiveness in comparison to the traditional instructions is not conclusive. There are studies to report increase or no effect in performance [1-4] in the flipped classes over the traditional lectures. Research is focused on students' perspective [1, 5]. Instructors are attracted to the flipped model because it allows, through other learning activities, focus during class time on reinforcing concepts conveyed in the videos, readings or some other out-of-class presentations. The classroom time becomes student-centered [6], because of the fertile environment for combining multiple types of active learning and classroom assessment techniques. Therefore, we can conclude that the flipped classroom involves two stages: the "In Advance" and the "Pre/in class." In the first stage, the instructor delivers the lecture through an online medium (and/or assigns reading) so that students are introduced to concepts before class, later to be used in applications for deep learning. The "Pre/In class" stage is of interest in this study. After students are presented with the new material before class, instructors use different approaches for different reasons/teaching goals to gauge student preparedness for class: online quizzes before class [4, 7, 8] (most commonly studied), beginning of class reviews [4], or other classroom assessment techniques. DeLozier and Rhodes [9] review some of these techniques: audience response, open questions, think-pair-share, student presentations. This paper introduces a review technique as way, among other uses, to highlight a concept of importance to a larger topic.

Purpose:

The purpose of this study is to introduce a new assessment technique that can be used by instructors to asses students' knowledge gained by watching the "In Advance" video-lecture and their ability to synthesize the information. A second investigation is into the effect of review condition, before a quiz, on students' performance on that quiz. Though the One Word Prompt Quiz is certainly an accountability check, it is the learning function of the quiz that is important. It helps students to engage in retrieval practice [10, 11] during a test [12], therefore increasing the probability for concepts to be correctly recalled or recognized in long term.

Methods:

The One Word Prompt Quiz consists of one-word prompt from the instructor, a word that is repeated in the videos watched by students before class. This word is of significance to the understanding of the topic and/or a part of the concept at hand. Students then have to recall the videos for that class session, identify the context in which that word was used and show understanding of the concept associated with that one word. They have three minutes on the clock to write definitions, explanations and/or draw for detail; however, they do not have to write down equations. These requirements limit the students in writing only the pertinent information, as opposed to memorizing the whole video.

The One Word Prompt Quiz was developed for the fully flipped course *Introduction to Fluid Mechanics* in the College of Engineering at the University of Georgia, with videos of 7-12 minutes in length. The quiz was administered once a week at the most, depending on the teaching goals for certain topics, and all quizzes account for 3% of the final grade. For key topics, rather than beginning the class with a review and explanation of the equations for the day, the instructor would administer the One Word Prompt Quiz as a ramp into the class activities. This will also encourage a long-lasting benefit of retrieval of information on a particular tricky part of a concept.

The quizzes were given in three conditions at the beginning of class, referred to as type of quiz. Each section of *Introduction to Fluid Mechanics* had a different type of quiz, though they might have received the same word.

1. Type A quiz: students closed all books and notes and the instructor provided the word connected to the concept. Students had three minutes to write their explanations.
2. Type B quiz: students were asked to close all notes and books, take 60 seconds to recollect and get into the mind frame of the class and topic discussed in the videos. The instructor provided the word at the end of the 60 seconds, and students were allowed three minutes to write their explanations.
3. Type C quiz: students are given 60 seconds to go over their notes and review the concepts in the videos for that class period. The instructor provided the word and students had three minutes to write their explanations.

At the end of the three minutes, the grader collected the quizzes and the instructor conducted a debrief on the quiz. The testing effect theory [10-12] as well as active learning principals emphasize the importance of debrief after any activity (individual or in groups). The quizzes were awarded points according to the general rubric below.

Table 1: One Word Prompt Quiz rubric

Points	Explanation
0	-Incorrect identification of topic. -The explanation/definition is wrong, though identification of topic might be correct. -Use of borrowed explanation/definition from a different class. *
1	-Correct identification of concept. -Some part of the explanation/definition/drawing is wrong or not connected to the Fluids context.*
2	-Correct identification of concept. -Good explanation/definition/drawing.
3	-Extraordinary explanation/definition and drawings to complement their argument.

Note: *students taking Thermodynamics at the same time as Introduction to Fluid Mechanics, might be discussing same topics, but from a different scientific perspective.

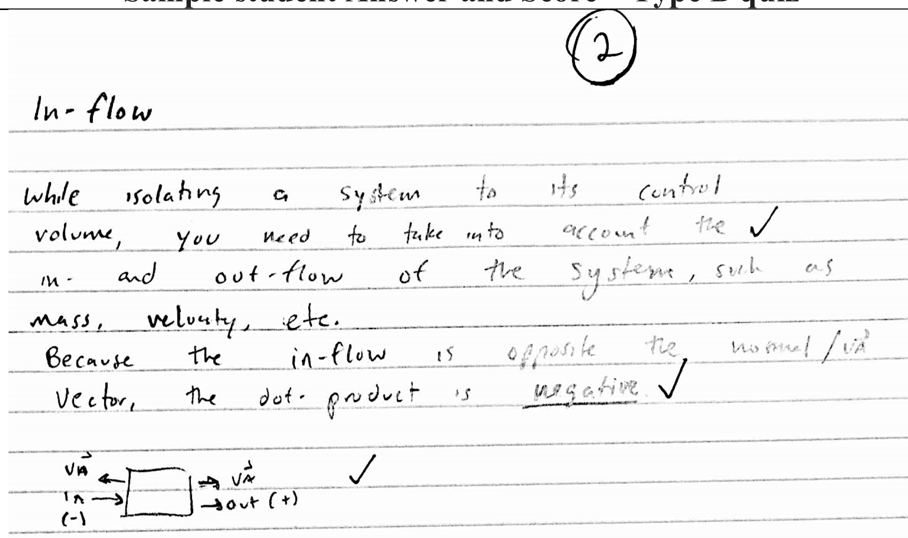
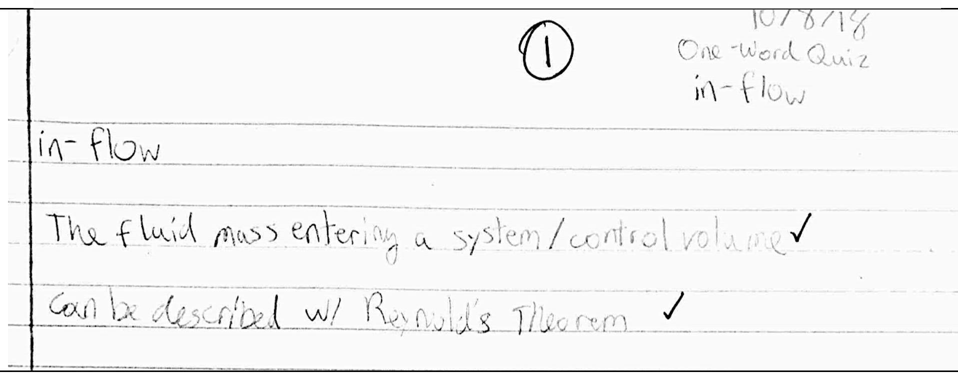
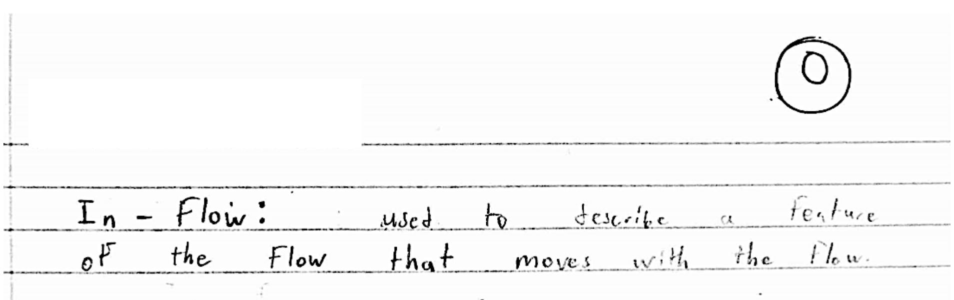
In Fall 2018, the instructor taught three sections of 39 students each and 89 students (58 males and 31 females) agreed to participate in the study. In all three sections, the students declared various engineering majors: mechanical, civil, environmental, biochemical and agricultural engineering. In the week that the One Word Prompt Quiz was administered, each section had one of the three types, utilizing a counterbalanced study design [13]. In this study design, all sections had all types of quizzes over the semester and the same word/concept was tested in multiple study conditions, thus reducing the word prompt difficulty as a factor in the analysis. The recorded types of five quizzes considered in this study are presented in Table 2.

Table 2: Recorded Quiz Type

	Section 1	Section 2	Section 3	Average Score (out of 2)
Quiz 1	A	B	C	1.27
Quiz 2	C	A	B	1.42
Quiz 3	B	C	A	1.27
Quiz 4	C	B	A	1.50
Quiz 5	C	A	B	1.49
Quiz Average	1.62±0.28	1.33±0.27	1.24±0.24	1.40
Grade Average (%)	77.72±12.14	76.16±11.66	74.13±7.12	76.00

A scenario of administrating the One Word Prompt Quiz is detailed here. The video that students had to watch "In Advance" sometime mid semester was titled "Conservation of mass". This video explained the importance of isolating a section of the fluid flow for analysis (control volume) and how to choose it. Also, the instructor explained and showed the equation to be applied for this concept, that can be summarized as: "change in storage plus mass flux out (of the control volume) minus mass flux in equals zero." An interesting outcome in the application of the conservation of mass concept is that the in-flow mass flowrate (mass flowrate being a topic discussed during a previous class) is negative in the equation, while the out-flow is positive. A detailed explanation is provided in the video as to the physics/mathematical reason. Understanding the reasons and the justification is of importance not only for the present topic, but of help in understanding some sign conventions later in the semester when discussing "Conservation of Momentum". The samples in Table 3 show how three students in Section 3 answered to the prompt "in-flow" and the respective score awarded according to the rubric (Table 1).

Table 3: Sample Student Answer to the Prompt "in-flow" after Watching "Conservation of Mass" videos

	Sample student Answer and Score – Type B quiz	
	 (2) In-flow While isolating a system to its control volume, you need to take into account the ✓ in- and out-flow of the system, such as mass, velocity, etc. Because the in-flow is opposite the normal/$\vec{n}$ vector, the dot-product is negative ✓ in (-) out (+) ✓	
	 (1) 10/8/18 One-Word Quiz in-flow in-flow The fluid mass entering a system/control volume ✓ Can be described w/ Reynold's Theorem ✓	
	 (0) In-Flow: used to describe a feature of the Flow that moves with the Flow.	

Results:

The average score was calculated for each type of quiz and illustrated in Figure 1. As expected, quiz of Type A (no reflection) had the lowest average of 1.07 ± 0.84. However, students performed better with Type B (reflection) with an average of 1.39 ± 0.81 and best by reviewing notes (Type C) with an average of 1.63 ± 0.74. This result might raise some questions regarding the quality of notetaking while watching the videos, how far in advance the videos have been watched and review of notes right before the quiz is announced. The average scores on quizzes, presented in Figure 2, do not reveal if there is a learning curve on how to take the quiz, but there might be an indicator of the depth of assessment (difficulty of the topic/word). Further investigation and analysis are necessary on a larger number of quizzes. The results in Table 2 indicate that students might need further instruction on the topics assessed during Quiz 1 and 3, as the class performed worst on those topics. In conclusion, this study proves that the reflection conditions before a quiz will influence the results of the quiz, but a combination of the conditions of quiz administration can be a better indicator of the students' grasp of a topic/concept from "In Advance" preparation.

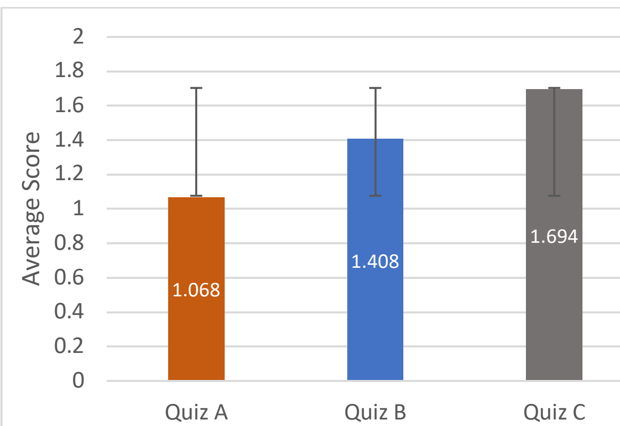


Figure 1: The Average Scores per Quiz Type (includes the illustration of standard deviation)

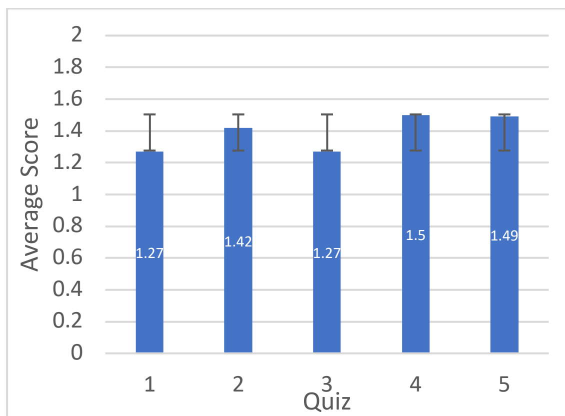


Figure 2: Average Scores per Quiz (includes the illustration of standard deviation)

Discussion:

The One Word Prompt Quiz is a new classroom assessment technique that can be used to evaluate students' knowledge gained from watching the videos required before class. When provided with the word from the video topic, students need to identify the relating context and/or concept and explain in their own words the topic/concept. The results of the quizzes can inform on the level of understanding of the concepts. This type of quiz may promote good notetaking habits, but further analysis is needed. This type of quiz requires a low level of preparation from the instructor and can be versatile to many types of classes; traditional or not. Instructors can use the One Word Prompt Quiz as a bridge-in [14] to their lesson plan. This quiz can also be adapted to a SRS (student response system) depending on the teaching goal or student learning outcomes [15]. It can be used when a huge volume of reading is assigned for less problem-solving-oriented classes. If there is a heavy load of concepts, a taxonomy can be provided for students to prepare for class according to the teaching goals.

Future Analysis:

Morris and Savadatti's research [16] showed that the number of full videos watching drops during the semester for a flipped class. A more in-depth analysis of the implementation of the One Word Prompt Quiz should be performed to investigate if there is a correlation between the administration of the quizzes and video metrics. Further analysis of the implementation of the One Word Prompt Quiz can provide insight in the level of students fulfilling the learning outcome related to communication of class topics.

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