Reflections about Using a Hybrid Inverted Classroom in a Sophomore Environmental Engineering Course

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Abstract

This study reports on student perceptions and performance using a Hybrid Inverted Classroom (HIC) in a sophomore level environmental engineering course. The class consists of thirteen, online learning modules administered through Canvas. Students were required to complete 10 modules with a score of 70 or better to pass. Each module had to be completed by a specified deadline. During class-time, the instructor used active learning activities including problem-based learning (PBL) to reinforce material covered in the recorded lectures. The instructor reviewed and answered questions about the online problems and topics that remained unclear to students. Pre-, midterm, and post- surveys were administered to ascertain student perception and their performance. Seventy-two percent of the students preferred the Hybrid Inverted format at mid-term. They rated their performance in regards to class attendance and online quizzes as high (nine). For completing the reading assignments and asking questions, students rated themselves lower at a seven.

Keywords

Inverted classroom, environmental engineering, active learning, WebEx.

Introduction

Professors are generally trying innovative methods to improve student performance in the classroom. Instructors have been using the inverted or flipped classroom pedagogy in some form for almost two decades. This inverted format has helped student achievement with active learning activities in the classroom and recorded lectures that students can view asynchronously outside of class. It also should allow instructors more time to interact with students during class time than would occur in a traditional lecture format.

Students do not necessarily improve when using an inverted classroom compared to the traditional lecture-based format, according to Fogarty[1]. The data did indicate that students reported spending less time per week on course material using the inverted classroom and statistically, their performance was the same as students in the lecture-based class. Other researchers[2] found that integrating active learning activities into an inverted classroom had a positive impact on students' attitude toward learning and improved their critical thinking skills. Prince[3] review of the literature supports all forms of active learning (collaborative, cooperative, and problem-based learning) in the classroom. Students will remember more content because of

active learning. A study by Velegol and Zappe[4] indicated that a more motivating classroom environment may be achieved in a flipped classroom. This is due to students receiving individual attention from the instructor.

Background

A decision was made to implement the "Hybrid Inverted" classroom pedagogy in the EVE 290 Introduction to Environmental Engineering for fall 2019. The major driving factors were to:

- Allow the students some flexibility in viewing the course materials.
- Let them set their own pace for the course with some strict deadlines.
- Provide more individual interaction with students.
- Move to online courses in the future.

EVE 290 is a 3-credit hour course required by all civil and environmental engineering students. There is a separate 1-credit, three-hour lab course that is taught independently. Professors taught the course in thirteen modules with students completing ten of them with a score of 70 or better to earn a C. Modules 1 through 8 were required while the remaining two could be selected by the student depending on their interest. There was at least one recorded video lecture and online quiz for each module. For the more in-depth modules, there were two or more recorded lectures and two online quizzes. Table 1 shows the names, the lessons and videos, the estimated time for, and the number of quizzes for completing each module. Instructors gave thirty-four lectures using WebEx Recording Editor (Cisco Webex) with an approximate viewing time of 19.5 hours.

Table 1. Course Module Number and Topic Area

Module #	Topic Areas	Lesson #: Time (min)	Quizzes
1	Environmental Engineering as a Profession	1:39	#1
2	Introduction to Environmental Engineering Calculations	2:32, 3:32	#2
3	Essential Chemical Concepts	4:52, 5:40	#3A and #3B
4	Biological and Ecological Concepts	6:22, 7:32, 8:26, 9:35	#4A and #4B
5	Design and Modeling of Environmental Systems	10:29, 11:42,12:29, 13:25	#5
6	Water Quality and Pollution	14:26, 15:21, 16:36, 17:22	#6A and #6B
7	Water Treatment	18:34, 19:30, 20:47, 21:26, 22:39, 23:40	#7A and #7B
8	Domestic Wastewater Treatment	24:28, 25:38, 26:31	#8
9	Air Pollution	27:23, 28:31	#9
10	Fundamentals of Hazardous Waste Site Remediation	29:31, 30:45	#10
11	Introduction to Solid Waste Management	31:28	#11
12	Risk Assessment	32:46	#12
13	Sustainability and Green Development	33:46, 34:53	#13

The minimum time to view 10 modules was 15.6 hours (Modules 1-8 plus 11 and 12). To view the 10 longest modules was 17.3 hours (Modules 1-9 plus 10 and 13).

Students were supposed to read the text and view the Webex videos prior to attending the in-class sessions. Sometimes, instructors presented mini-lectures on difficult topics. They also completed example problems during the face-to-face meetings. Often, instructors dedicated the in-class sessions to answering student questions and having them work together in teams of three or four to solve problems collaboratively. Students submitted these problems at the end of the class period. These problems were similar and, in some cases, identical to the problems in the online quizzes.

Final course grades would be determined based on their performance on the eight required modules and the two optional modules along with the in-class collaborative. No tests, mid-term, or final examination were required in this offering for the course.

Methods

Professors administered surveys at the beginning, midway through, and at the end of the fall 2019 term. These surveys allowed students to respond to the Hybrid Inverted approach. The surveys also provided students with an assessment of the students' performances. The pre- and post-surveys consisted of fifteen questions and were modeled after the one used by Kecskemety and Morin[5]. The students were also asked to indicate their preferred teaching pedagogy: a traditional lecture-based classroom, a partially traditional and partially flipped, or an inverted classroom. Four open-ended questions were listed on the pre-survey to allow students to provide written comments about their experience using the Inverted classroom approach, if they believed that an Inverted classroom would enhance their learning experience, had they used WebEx before, and any other comments that they wished to share about the upcoming semester. Appendix A shows the pre- and post- survey. The midterm survey was given to acquire feedback from the students regarding their perceived performance and what changes they could implement to improve their performance. Appendix B shows the midterm survey.

Results and Discussion

Pre-Survey
Twenty-five students completed most of the questions on the pre-survey found in Appendix A. Seventy-six percent of the students picked the partially traditional and partially flipped class approach, while sixteen percent selected the traditional lecture approach. The remaining eight percent selected the inverted classroom. Of the twenty-five students, only twenty-three answered their experience with the inverted classroom. Thirty-nine percent said that they had experienced the inverted classroom while sixty-one percent had not.

It was encouraging to learn that students agreed (an average rating of 3.9 to 4.2) with the following questions (3, 4, 11, 12, and 13).

- Student agreed that the inverted classroom allows the instructor to focus on topics that are more difficult to understand (3.9 ± 0.7).
- Students agreed that the inverted classroom makes good use of technology (4.0 ± 0.8).

- Students agreed that the inverted classroom helps them because they can revisit the preparation material whenever they need to (4.1 ± 0.8).
- Students agreed that the inverted classroom makes them feel more responsible for learning (4.2 ± 0.7).
- Students agreed that the inverted classroom helps them to become a better self-learner (4.0 ± 0.7).

Students slightly agreed (an average rating of 3.3 to 3.8) with the following questions (1, 2, 5, 6, 7, 9, 10, 14, and 15).

- Students slightly agreed that the inverted classroom gave them immediate feedback (3.5 ± 0.7).
- Students slightly agreed that the inverted classroom is an efficient use of class time (3.4 ± 0.7).
- Students slightly agreed that the inverted classroom makes class time more engaging (3.7 ± 0.8).
- Students slightly agreed that the inverted classroom creates an active learning environment (3.8 ± 0.8).
- Students slightly agreed that the inverted classroom helps them to learn at a deeper level (3.5 ± 1.0).
- Students slightly agreed that the inverted classroom personalizes learning to them. (3.5 ± 0.7).
- Students slightly agreed that the inverted classroom allows them to learn at their own pace. (3.8 ± 0.9).
- Students slightly agreed that the inverted classroom encourages them to learn from their peers. (3.7 ± 0.8).
- Students slightly agreed that the inverted classroom grows their life-long learning skills. (3.8 ± 0.7).

Student's ratings fell in the neutral range (an average rating of 2.8 to 3.2) only on Question #8.

- Student's ratings were neutral toward the inverted classroom accommodating their learning style (3.2 ± 1.0).

Midterm Survey

Table 2 shows the results of the students rating their performance with regard to class attendance, online quiz results, reading assignments, and asking questions in class.

Table 2. Performance Assessment by Students in Four Areas.

Performance Area	Average	Standard Deviation	n
Class attendance	9	2	25
On-Line Quizzes	9	1	25
Reading Assignments	7	2	25
Asking Questions	7	2	25

Students rated themselves very highly on attendance and on their online quiz performance. Some of the students were overly optimistic in rating their class attendance since four students had missed 8.82% of the class, one had missed 11.76% of the class, three had missed 17.65% of the classes, and one individual had missed 20.59% of the classes. They rated themselves lower on the reading assignments and asking questions in class. The responses to the open-ended questions on the survey and to the questions raised in class, led instructors to believe that they do not read the text or take notes while watching the videos. In some instances, it appeared that students went directly to the online quizzes without reading or watching the videos.

- Eighteen out of twenty-five students (seventy-two percent) state that they prefer the Hybrid Inverted Classroom (HIV).
- Ninety-one percent of the twenty-three students that answered Question #3 indicated that they preferred working in a group.
- One-hundred percent of the students like the idea of completing only ten of thirteen modules for grade.
- Sixty-seven percent of students stated that course material was presented in the right amount of detail, twenty-one percent thought there was too little detail presented, and the remaining twelve percent thought there was too much detail presented.
- One-hundred percent of the students felt that the number of online assignments were the right number.
- Seventy-six percent of students stated that the pace of the course was about right, sixteen stated that the course was too slow, and eight percent said that the pace of the course was too fast.

Post-Survey
Twenty-three students completed the questions on the post-survey found in Appendix A. Fifty-six percent of the students picked the partially traditional and partially flipped class approach, while thirty-five percent selected the traditional lecture approach. The remaining nine percent selected the inverted classroom.

Students agreed (an average rating of 3.9 to 4.2) with the following questions (3, 4, 10, and 12).

- Student agreed that the inverted classroom allows the instructor to focus on topics that are more difficult to understand (4.0 ± 0.9).
- Students agreed that the inverted classroom makes good use of technology (4.0 ± 0.8).
- Students agreed that the inverted classroom allows them to learn at their own pace. (4.2 ± 0.9).
- Students agreed that the inverted classroom makes them feel more responsible for learning (4.2 ± 0.5).

Students slightly agreed (an average rating of 3.3 to 3.8) with the following questions (1, 2, 6, 11, 13, 14, and 15).

- Students slightly agreed that the inverted classroom gave them immediate feedback (3.6 ± 0.9).

- Students slightly agreed that the inverted classroom is an efficient use of class time (3.4 ± 0.7).
- Students slightly agreed that the inverted classroom creates an active learning environment (3.5 ± 0.8).
- Students slightly agreed that the inverted classroom helps them because they can revisit the preparation material whenever they need to (3.5 ± 1.0).
- Students slightly agreed that the inverted classroom helps them to become a better self-learner (3.8 ± 0.8).
- Students slightly agreed that the inverted classroom encourages them to learn from their peers. (3.8 ± 1.0).
- Students slightly agreed that the inverted classroom grows their life-long learning skills. (3.7 ± 0.8).

Student's ratings fell in the neutral range (an average rating of 2.8 to 3.2) on the following questions (5, 7, 8, and 9).

- Student's ratings were neutral toward the inverted classroom making class time more engaging (2.8 ± 0.9).
- Student's ratings were neutral toward the inverted classroom helping them to learn at a deeper level (2.8 ± 1.1).
- Student's ratings were neutral toward the inverted classroom accommodating their learning style (3.0 ± 1.3).
- Student's ratings were neutral toward the inverted classroom personalizing learning to them. (3.2 ± 0.7).

Conclusions

During fall 2019, a hybrid inverted classroom approach was implemented in EVE 290 Introduction to Environmental Engineering. A pre-, midterm, and post- survey was administered to acquire feedback on student attitudes toward the (HIC) and its impact on their performance. On the initial survey, seventy-six percent of the student preferred the partially flipped/partially traditional classroom approach to learning. Responses to the fifteen-question survey showed that the HIC had a positive impact on their learning and performance in the course. The mid-term survey indicated that students gave themselves high ratings (nine) on class attendance and performance on online surveys. The ratings on completing reading assignments and asking questions were two points lower at a seven; this indicated that considerable improvement could be accomplished in those areas. Seventy-two percent of the students still preferred the HIC approach at midterm. Students prefer to work in groups and over seventy-five percent of them believe that the course is presented in the right amount of detail and the pace of the course was about right. Attitudes toward the HIC had shifted somewhat by the end of the course. Following the post-survey, fifty-six percent of the students selected the partially traditional and partially flipped course, down from seventy-six percent initially. Thirty-five percent of students preferred the traditional lecture format at the end of the course versus sixteen percent at the beginning. Student's ratings were neutral toward the HIC making class time more engaging, helping them to learn at a deeper level, accommodating their learning styles, and personalizing learning to them.

Eighty-five percent of the students earned an A (seventy-eight percent of the students indicated they expected to receive an A) in the course using the HIC approach. This compares to eighteen and thirty-three percent of the students earning an A when the course was taught in the traditional lecture format on two previous occasions.

References

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Appendix A: Pre-Survey and Post-Survey

The "Flipped" or "Inverted" classroom model is based on the initial learning experience and exposure to a concept occurring outside of the classroom, before the students experience the material in-class. This outside of class exposure may include activities such as reading, videos, tutorials or other learning activities. The in-class activities are used to reinforce this knowledge and minimal lecturing is used in the classroom setting. And only used to help reinforce and explain difficult concepts.

Please check one of the following preferred classroom approaches.

Traditional lecture-based classroom	
Partially traditional and partially flipped classroom	
Flipped or inverted classroom	

Please circle yes or no for the following question.

Have you experienced the Flipped or Inverted classroom before? Yes or No

Please rate each of the following questions on a 1 to 5 Likert scale:

1—Strongly disagree; 2—Disagree; 3—Neutral; 4—Agree; and 5—Strongly agree

1. The flipped classroom approach lets me get immediate feedback while working on homework and activities._____
2. The flipped classroom approach does not use class time efficiently._____
3. The flipped classroom approach lets my instructor focus primarily on topics that are more difficult to understand._____
4. The flipped classroom approach does not make good use of technology._____
5. The flipped classroom approach makes class time more engaging._____
6. The flipped classroom approach creates an active learning environment._____
7. The flipped classroom approach helps me to learn topics to a deeper level than a traditional classroom._____
8. The flipped classroom approach accommodates my learning style._____
9. The flipped classroom approach personalizes learning to me._____
10. The flipped classroom approach does not allow me learn at my own pace._____
11. The flipped classroom approach helps me because I can revisit the preparation material whenever I need. _____
12. The flipped classroom approach makes me feel more responsible for my own learning._____
13. The flipped classroom approach helps me become a better self-learner._____
14. The flipped classroom approach does not encourage me to learn from my peers._____
15. The flipped classroom approach grows my life-long learning skills._____
- Have you taken a course that utilizes the "Flipped" classroom pedagogy?
- Do you believe that a "Flipped" classroom will enhance your learning experience? Why or why not?
- Have you used WebEx in any of your previous courses? If so, did you like or dislike using it? If you have not used it, do you have anxiety or other concerns about using it?
- Any other comments that you wish to share about the upcoming semester?

Appendix B: Midterm Survey

1. Please rate your performance in the course to date on a scale from 1 to 10 (1 lowest).
   Class attendance _____
   On-line Quizzes_____
   Reading Assignments _____
   Asking questions _____
2. Is the "Hybrid Inverted" classroom approach appealing to you? Explain.
3. Do you prefer to work alone or in a group? Explain.
4. How do you like completing 10 out of 13 learning modules? Explain.
5. Is the course material being presented in too much, too little, or about the right amount of detail? Explain.
6. With regard to the online assignments, are there too many, not enough, or about the right number? Explain.
7. Is the pace of the course too slow, too fast, or about right? Explain.
- Discuss any changes that you would make in the course.
- Discuss what you feel **you** could do to improve your performance during the remainder of the course.