

Enriching the Experiential Learning Experience through Inverted Classrooms

Peter Rogers, Ph.D., PE and Clinton Martin, Ed.D., MSCA

Georgia Southern University

Abstract

Concern that larger class sizes are reducing student-instructor interaction and impacting student learning has motivated educators to look for innovative teaching and classroom management techniques. One approach involves combining the features of an “inverted classroom” with an experiential learning environment. With the inverted (flipped) classroom model providing students with lesson material outside the classroom through an online environment, class time is devoted for experiential learning activities that complement the online lessons while also stimulating critical thinking and reflection. This paper discusses how the inverted classroom was used in collaboration with experiential learning activities in two required courses from two separate programs. In doing so, it also reveals several interesting findings regarding student engagement, the role of a collaborative classroom environment in creating a learning community, and the impact of experiential learning activities in developing problem solving skills.

Keywords

Inverted classroom, experiential learning, problem solving, construction management, civil engineering

Introduction

This section provides a general orientation of inverted (flipped) classrooms; both in terms of their general characteristics as well as a brief history of their evolution. It also provides a perspective on how inverted classrooms have been used to improve student engagement and foster experiential learning and critical thinking.

The basis of an inverted classroom is to transform the classroom environment from a teacher-centric environment (where instructors lecture and students observe) to learner-centric environment where students are engaged in hands-on learning activities during class time. This is achieved by having students receive lecture material (PowerPoints, videos) outside the classroom (online) prior to class, then spend class time applying concepts through problem-solving and experiential learning activities with the support of peers and the course instructor. In a traditional lecture-based classroom students perform lower level cognitive tasks (Bloom’s taxonomy levels 1 & 2: knowledge and comprehension) during the lecture and are expected to perform higher level cognition on assignments and exams (Bloom’s taxonomy levels 3, 4, 5 and sometimes 6: application, analysis, synthesis, and sometimes evaluation)¹. In the flipped model (see Figure 1 below) lower level cognition tasks are done out-of-class and higher level cognitive tasks are done in a collaborative classroom environment.

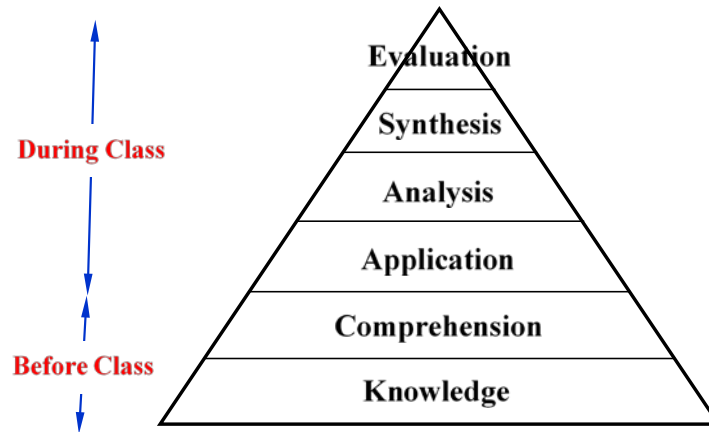


Figure 1. Bloom's Taxonomy as it relates to the Inverted Classrooms

Evolution of the Inverted Classroom Approach and its Impact on Experiential Learning

Flipped learning arguably was pioneered by two high school science teachers, Jon Bergmann and Aaron Sams, in the spring of 2007. Both Bergmann and Sams were chemistry teachers at Woodland Park High School in Woodland, Park Colorado. The first flipped classroom sessions used software to voice record over PowerPoint lectures. At the time students who attended Woodland Park High School would often miss class to attend school sponsored extra-curricular events. The first recorded lectures were used as a way to teach students who could not attend all class sessions due to scheduling conflicts. After both teachers began using the model they noticed how flipping improved student interaction both among peers and with the teacher^{2, 3}.

Flipped learning is a type of learner-centric model. The learner-centric model in America is mostly attributed to early progressive educator John Dewey. John Dewey suggested that the process of learning was more important than goals or predetermined learning outcomes. Further he suggested that if learning is to be successful it requires the learner to take an active role in that process⁴. John Dewey believed that "reflection involves not simply a sequence of ideas, but a consequence—a consecutive ordering in such a way determines the next as its proper outcome, while each in turn leans back on its predecessors."⁵

The authors believe that inverted learning is a form of active learning that focuses on the learner as the owner of the knowledge gained from participating in classroom activities. Thus the learner is required to use social and problem solving skills work on projects in the classroom. The learner in this model is responsible for gaining requisite knowledge before coming to class, but is guided by the use of technology to create learning modules relevant to the content of the two courses.

Experiential learning can be defined as learning through experience via reflection on the learning process⁸. The authors feel that the flipped classroom as applied in this study is a form of experiential learning. It should be noted that experiential learning is a form of active learning that utilizes reflection as an added component. In the inverted classroom the instructor is able to assess student learning as it happens and improve student learning outcomes. This allows

students to take ownership of their learning and reflect on weaknesses, strengths and build competence (and arguably confidence).

The use of flipped classrooms is certainly not new to engineering education as can be seen when searching ASEE conference proceedings. A search using the terms “flipped classrooms” and “inverted classrooms” returns 144 articles for 2015 and 80 articles for 2016 (as of October, 2016) across multiple disciplines. As expected, there is a lot of variance regarding the content of the articles. Whereas some articles focus on identifying the “lessons learned” from case studies in which inverted classrooms were used for various types of courses at different academic levels, others spotlight instructor and student observations pertaining to benefits and limitations of the approach. Other articles address pedagogical-based strategies for improving its implementation. One such paper that contains many of these topics and was used in the design and implementation of our hybrid classroom came from Swartz, Butler, and Laman⁷. In this paper the authors report on the use of a flipped classroom in three Civil Engineering courses taken at three different academic levels (sophomore, junior, senior). While their paper did not address a method for direct assessment, it provides valuable insight regarding the merits and challenges associated with inverted classrooms as well as practical strategies and insights for its application. In a similar study by Gross and Musselman⁶ involving the use of a flipped classroom approach in several courses related to structural design, the authors used courses taught in the same department which is similar to this study, but also included assessment results taken from quizzes, problem sets, and design projects. Their assessment also included an end-of-semester survey that summarized student perspectives on the inverted model. Our study differs from the aforementioned studies in two important areas: i) our courses are from two distinct programs (civil engineering and construction management), ii) our post-implementation survey goes beyond evaluating students’ overall perspectives of the inverted classroom model to include specific insights regarding how the inverted model impacted experiential learning. In addition to qualitative data collected through the end-of-class surveys, quantitative data was provided through a direct assessment of student performance of each course’s student learning outcomes (SLOs).

Methodology

This section provides background information regarding the courses used in this study, details relating to how the inverted classroom model was used in each course, and the methodology used for collecting the qualitative and quantitative data. In doing so, it identifies the components of the inverted classroom component common for each course while also addressing the notable differences as to how the instructor implemented inverted classrooms and the types of experiential learning activities that were used.

Implementation

Course: Civil Engineering Fluid Mechanics

This course is a required course in the Civil Engineering curriculum usually taken during the second semester of the sophomore year. Enrollment is normally limited to 24 students due to the space limitations of the laboratory (the course has both lecture and lab components). As students arrive for class, the instructor collects a “ticket” from each student which contains a lesson-

specific assignment used to measure their understanding of the key concepts covered in the online lesson. Like the lesson itself, the assignment (ticket) is also posted online. Most of the questions within the assignment are short answer, addressing knowledge and comprehension levels within Bloom's Taxonomy. However, normally there is one or two computational-based questions requiring students to rework an example from the online lesson (with different variables) or a similar problem addressing the application and analysis levels within Bloom's. In lieu of the importance of pre-class preparation in the inverted classroom approach, students entering the classroom without their completed "ticket" are considered absent for the class (counting against their attendance grade) but are allowed to participate in the problem solving portion of the class. As the tickets are collected, each is evaluated for completeness and originality (i.e. making sure that no two tickets are direct copies of each other). Students identified as having copied tickets are not given credit for attending that day's class.

Having collected the tickets, each class starts with a 10~15 minute lesson overview in which the instructor highlights the concepts covered in the online lesson. In doing so, he addresses the concepts addressed within the "ticket" while also emphasizing how the lesson's content relates to previous and/or upcoming lessons, the course, and the profession. The instructor intentionally limits the lesson overview to 15 minutes based on the finding from Swartz, Butler, and Laman whose literature review identified that typical student attention spans range from 5-15 minutes⁷. The remainder of the class time is devoted to a variety of hands-on learning activities including: problem solving sessions, computer-based activities with commonly-used software (MS Excel, Flow Master, etc.), and laboratory activities (formal and informal). The majority of these activities are performed in groups of three (which the instructor changes periodically) which provides a collaborative environment for students to share ideas and pose questions to the students that require critical thinking. As opportunities surface, the instructor makes a concerted effort to extend the class content to the synthesis and evaluation levels within Bloom's Taxonomy by initiating class discussions that explore design applications/alternatives or having students defend their problem solving approach. As an example, when covering a lesson addressing buoyancy force, the instructor showed the class a picture of a tension-leg platform (a common offshore structure) and asked students to reflect on how the buoyancy force would be applied to its design.

As part of the process of working through their learning activity (and at the completion of the assignment which is graded in their presence), students reflect on their product (the answer), the assumptions, and the thought process used in arriving at the answer. This reflection occurs both within their group (students defending answers/approaches with other students) and with the instructor. This reflection is a key component of the experiential learning process and is what separates it from hands-on learning.

Course: Introduction to Structures

This course is a required in the Construction Management curriculum and usually taken during the first semester of the sophomore year. Unlike the fluid mechanics course which limits enrollment due to laboratory considerations, this course is a lecture only style course with enrollment that varies from 40 to 50 students per semester. Because of the difficulty in reviewing this many tickets within a limited time frame at the beginning of the class session, the instructor in this course uses on-line quizzes rather than collecting physical "tickets". Like the

“tickets” the on-line quizzes include questions testing knowledge and comprehension as well as computational-based questions that require students to rework an example from the online lesson or a similar new problem. Likewise, students who don’t score a minimum quiz grade of 70%, or don’t attempt the quiz, are considered absent for the class (counting against their attendance grade) but are allowed to participate in the in-class learning activity.

Aside from the aforementioned difference regarding how pre-class preparation is evaluated, the methodology used in implementing the inverted classroom (lesson overview, group size, hands-on learning activities, encouragement and emphasis on reflection, etc.) in this course are similar to that mentioned for the fluid mechanics course.

Qualitative Data Collection

At the completion of each course, students completed a post-implementation questionnaire in order to gain insight on their overall perspectives of the inverted classroom as well as evaluate the perceived effectiveness of the in-class activities. As shown in the questions below, several of the questions relate specifically to the use of reflection in the experiential learning process.

Quantitative Data Collection

Quantitative data for the study was collected by analyzing student performance for each course’s student learning outcomes (SLOs). Each SLO was evaluated using samples taken from assignments, laboratories, and exam questions. As shown in Tables 1 and 2 below, data for the traditional (i.e. non- inverted) classroom was taken from the Spring 2016 semester for the Introduction to Structures course and the Spring 2015 semester for the Civil Engineering Fluid Mechanics course. Data for the inverted courses was taken from the Fall 2016 semester for the structures course and the Spring 2016 and Fall 2016 semesters for the fluid mechanics course. Whereas one semester of inverted classroom data was available for the structures course, two semesters of data was available from the fluid mechanics course.

For consistency, the authors made every attempt to use either identical (or very similar) samples when comparing student performance across multiple semesters. For example, when evaluating SLO 3 (investigate and assess the load paths through elementary structural systems) for the Introduction to Structures course, the authors used the same homework and exam problems as samples for both Spring 2016 and Fall 2016 semesters.

Results

This section presents both the qualitative results, through a questionnaire which addresses the students’ perspectives of the inverted classroom and how hands-on learning activities impacted their understanding of the subject matter, and quantitative results as measured through student performance on each course’s SLOs.

Post-implementation Assessment

At the completion of each course, the students completed a questionnaire aimed at assessing their views regarding the inverted classroom model and how the various low stake experiential

learning activities impacted their understanding and learning of the subject matter. The following provides a representative sample of the comments received from the questionnaire:

1. *What did you like most about the inverted classroom?*

- The online lessons helped me with time management and provided me more flexibility. They also helped me be responsible for my own learning.
- I preferred spending the time reviewing the lessons rather than struggling with homework calculations.
- The tickets and quizzes forced me to review the material before class.
- Seeing the material before class made it much easier to understand during class.
- The lessons were clear and the additional videos really made the class interesting.
- The tickets helped me stay on track and not fall behind.

2. *Was there anything about the inverted classroom that you did not like?*

- I did not like having to go over and understand the entire lecture outside of class.
- I would like more in-class lectures and not have to do all of it on my own.
- If you get behind on one of the online lessons it hurts you immensely. Does not leave any room for error.
- It didn't allow a lot of time for professor to do example problems in class.
- Some classmates came to class unprepared and didn't contribute.
- With some of the more-complex lessons, I had to come to class with specific questions.

3. *If you could offer one suggestion to improve the inverted learning experience, what would it be?*

- Provide more explanation within the online lessons and show how to do the math step by step.
- Use more videos with your examples (like the ones used in the first half of the course).
- Some of the lessons were much easier when compared the in-class problems.
- Post all the tickets at the beginning of the course so I could print them all out at once (since I don't own a printer).
- Cover less information with each online lesson so it isn't so difficult to grasp everything being discussed.
- It would nice if the in-class assignments were completed individually.

4. *Do you feel that the in-class activities (problem sessions, computer labs, etc.) helped you learn the class material?*

- The activities helped me actually understand the material instead of just memorizing notes that were mindlessly jotted down.
- It gave us more time with the teacher in the classroom to practice and learn with his help.
- In class sessions forced me to learn the material rather than going home and looking up the answer.

- We were able to work through complex problems (harder than on-line examples) since the professor was there to guide us.
- In-class problem sessions made me take the course more seriously.
- The problem sessions forced me to do the homework and ask questions.

5. *Did the in-class activities provide you with opportunities to reflect (with teammates and/or the instructor) on how (assumptions, approach, etc.) you arrived at your answers and the answer itself?*

- Whoever within the group knew how to solve the problem, showed the others.
- Working in groups helped me see different ways to solve problems and learn.
- It was fun to bounce ideas off other people and brainstorm.
- Collaboration with my peers helped me identify common errors.
- I liked discussing within the group how we came up with the answers.
- I enjoyed doing the problems with classmates and learning from each other.

6. *How has flipped learning helped you to learn through experience?*

- It helped me learn on my own and practice with others.
- I liked having the ability to ask peers and the professor for immediate help.
- It made me put forth more effort both during and outside of class, which is a positive.
- Helped my learning, more than any other college class.
- I was challenged in every session with the approach I take on different problems.
- Working in a group forced me to communicate with others and leave my shell.

Performance Based Measures

Table 1 shows a comparison of student performance for the seven SLOs used in the Introduction to Structures course for the traditional (Spring 2016) and inverted (Fall 2016) classrooms. Except for SLO 6, data for the other six SLOs was compiled from a minimum of four samples taken from a combination of homework, lab reports, and exams. In the case of SLO 6, due to the subjective nature of the outcome and difficulty in obtaining a direct measure, data for this outcome came from an end-of-course questionnaire in which each student performed a self-assessment of this SLO using a 1~5 scale.

The data reveals a general trend in which students performed better in the inverted classroom than in the traditional classroom. The largest improvements (12.8% and 13.1%) occurred in SLO 3 and SLO 5. The smallest improvements (1.1%) occurred within SLO 2 and SLO 7. The average improvement across all SLOs was 4.4%. The large improvement in SLO 3 and SLO 5 (topics which students traditionally find to be very challenging) is most likely related to the collaborative environment of the in-class problem solving session in which students helped each other while also having more one-on-one interaction with the instructor.

Table 1. Comparison of Student Performance in Course SLOs for Traditional and Inverted Classrooms – Introduction to Structures

Student Learning Outcomes (SLOs) for the Introduction to Structures	Average Student Performance	
	Spring 2016	Fall 2016
1. Apply fundamental structural concepts, theories and principles in common construction topics.	76.8%	79.4%
2. Solve problems using standard analysis and design procedures with the application of trigonometry.	78.0%	79.1%
3. Investigate and assess the load paths through elementary structural systems.	74.0%	86.8%
4. Choose safe and economic structural elements.	78.1%	86.6 %
5. Analyze basic material and shape properties.	74.9%	81.0%
6. Acquire skills for self-directed learning.	81.3%	83.0%
7. Recognize structural terminology for interaction with engineers and architects.	86.1%	87.2%

Table 2 shows student performance for the eight SLOs used in the Civil Engineering Fluid Mechanics course for the traditional (Spring 2015) and inverted (Spring 2016, Fall 2016) classrooms. Observe that there are two semesters of SLO data for the inverted classroom since this course has used an inverted format for one academic year. Similar to the data collection process for the Introduction to Structures course, data for all eight SLOs was compiled using a minimum of four samples comprised of homework, lab reports, and exams.

Data from Table 2 indicates that, in all but one case (SLO 4), students performed better in the inverted classroom than the traditional classroom. The largest improvement (range of 4.3% to 5.5%) occurred in SLO 1 and SLO 8, with negligible improvement (range of -0.6% to 0.3%) occurring with SLOs 4 and 7. Comparing student performance within the two semesters using the inverted classroom, the average improvement during the Spring 2016 semester was 2.5% while the average improvement for the Fall 2016 semester was 2.8%. The minor improvement from the Spring 2016 and Fall 2016 semesters is likely because of improvements to the online videos and in-class exercises by the instructor in the Fall 2016 semester based on student feedback from the previous semester.

Table 2. Comparison of Student Performance in Course SLOs for Traditional and Inverted Classrooms - Fluid Mechanics

Student Learning Outcomes (SLOs) for the Fluid Mechanics Course	Average Student Performance		
	Spring 2015	Spring 2016	Fall 2016
1. Determine pressures and forces on submerged bodies.	78.1%	83.1%	82.6%
2. Analyze flow rates, velocities, and energy losses for fluid systems.	80.4%	83.6%	84.1%
3. Apply the laws of conservation of mass, momentum, and/or energy to static fluids and general fluid flow.	83.4%	85.2%	85.9%
4. Analyze fluid flow in pumping systems, turbines, and pipeline components.	82.0%	81.6%	82.0%
5. Perform a fluid mechanics based laboratory experiment and analyze the data.	80.7%	83.8%	81.4%
6. Write laboratory reports that are professional and communicate effectively.	81.0%	84.1%	87.2%
7. Apply modern tools (spreadsheets, etc.) for fluid mechanics applications.	86.4%	86.7%	85.8%
8. Analyze flow (normal depth, Froude number, etc.) in common open channel structures such as channels.	80.8%	85.0%	86.3%

Discussion

By combining the features of an inverted classroom with an experiential learning environment, the authors were able to transform two courses from teacher-centric environments into learner-centric environments where students were engaged and participated more in the learning process. The inverted (flipped) classroom played a critical role in this transformation by freeing up class time for experiential learning activities aimed at stimulating critical thinking and reflection.

Quantitative results from the study clearly indicate a significant improvement in student performance of both courses' SLOs with an average increases of 2.7% and 4.4% for the Civil Engineering Fluid Mechanics Introduction to Structures courses respectively. Results from the students' post-implementation questionnaires suggests that the combination of the inverted classroom and experiential learning activities improved their understanding of course material while also empowering them to take ownership of their learning. In the process, they learned to work in a collaborative environment, were able to reflect on their own strengths and weaknesses, and built confidence in their ability to solve problems.

The following summarizes the both the students' and instructors' observations with regard to the inverted classroom and the use of experiential learning activities:

Observations relating to the inverted classroom:

- Students prefer the collaborative in-class problem solving environment to the traditional method of using homework assignments as a student's first exposure to problem solving.
- The online environment allows students to review lesson material at their own pace. Whereas advanced students liked the freedom to move quickly through material, students struggling with these courses were able to move at a slower pace (replay videos, take notes on slides, etc.).
- The inverted classroom provides an environment that fosters creativity and allows instructors to use class time for more challenging and engaging activities. This provides opportunities to expand the class beyond the original learning outcomes while sparking student interest in their major.
- Transitioning students from passive to active participants in the learning process empowers them to take responsibility for their learning while also developing self-directed learning skills. These skills are vital in both civil engineering and construction management professions which require continuous learning.
- Assisting students with their assignments during class time minimizes the need for office hours and frees up time for instructor to work on other tasks. This is especially true for instructors that evaluate student work in class.
- The completion of pre-class preparation (reviewing videos, taking quizzes, completing tickets, etc.) is vital to the success of inverted classes. It's imperative that instructors hold students accountable for this work.

Observations relating to the experiential learning activities:

- While the in-class learning activities provide students with opportunities to gain hands-on experience, the real learning occurs as students reflect (with each other and the instructor) on the thought process used in arriving at the answer.
- Experiential learning activities have to be carefully crafted to include a reflection component. Without reflection, the activity is only a hands-on learning experience.
- Instructors should anticipate some level of resistance from certain students who are solely interested in passing the class and are not interested in active learning and reflection.
- Instructors can facilitate the transition from an 'answer only' to reflective course environment by talking with the students beforehand about experiential learning and how (and why) experiential learning activities will enhance their learning.

References

- 1 Anderson, Lorin and Krathwohl, David, *A Taxonomy for Learning, Teaching and Assessing: a Revision of Bloom's Taxonomy*, Longman Publishing, New York, 2001.
- 2 Bergmann, J. and Sams, Aron, "Flipped Learning: Maximizing Face Time." *TD*, 68(2), 2014, 28-31.
- 3 Bergmann, J. and Sams, Aron, *Definition of Flipped Learning*. *Flipped Learning Network*. 2014, Retrieved from: <http://flippedlearning.org/definition-of-flipped-learning/>
- 4 Dewey, John. *Democracy and education: An introduction to the philosophy of education*. WLC Books, New York, 2009.
- 5 Dewey, John. *How We Think*. D.C. Heath and Company, Boston, 1910.
- 6 Gross, S. and Musselman, E. "Observations from Three Years of Implementing and Inverted (Flipped) Classroom Approach in Structural Design Courses." *American Society for Engineering Education Annual Conference*, Seattle, GA, 2015, p.26.1195.1-21.
- 7 Swartz, B., Velegol, S., and Laman, J. "Three Approaches to Flipping CE Courses: Faculty Perspectives and Suggestions", *American Society for Engineering Education Annual Conference*, Atlanta, GA, USA, 2014, p.23.1249.1-14.
8. University of Texas at Austin, Faculty Innovation Center, 2016, retrieved from: <https://facultyinnovate.utexas.edu/teaching/engagement/experiential-learning/defined>.

Peter D. Rogers

Dr. Peter Rogers is an associate professor in the Department of Civil Engineering and Construction Management at Georgia Southern University. Prior to joining the University, he worked at the Institute for Water Resources and spent several years working throughout Latin America on rural and urban water and sanitation projects with a variety of international engineering and aid organizations including the United States Agency for International Development (USAID) Honduras. Peter's interests are in water and sanitation systems, hydraulics, water resources, public works management, and developing country water issues.

Clinton Martin

Dr. Clinton Martin is a Senior Lecturer in the Department of Civil Engineering and Construction Management at Georgia Southern University. He has worked in the department since 2008. He has a Doctorate in Education and a Master of Science in Construction Administration. Before working at Georgia Southern he was an Estimator and Field Manager for a Federal Contractor. Dr. Martin is coordinator of the Senior Capstone Course, adviser to the Construction Management, and coach of the Design Build Institute of America student competition team. Currently he is working with Habitat for Humanity on numerous service projects.