Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
ASEE
Paper ID #48579

Let the students lecture! Programmed peer instruction in foundational engineering courses

Dr. Seth Norberg, Northern Michigan University

Let the students lecture! Programmed peer instruction in foundational engineering courses

Abstract:

Building on a previous variation on the flipped classroom concept, and combining aspects of technical communication and peer instruction, each student in both the fluid mechanics and thermodynamic courses prepare and present the day's lesson material to their classmates. The courses within the Mechanical Engineering Technology major of the Engineering Technology Department at Northern Michigan University are required for the major and are typically comprised of senior engineering students. The lessons are selected early in the semester when the course schedule is distributed and students with a strong preference can volunteer for a certain topic. The assignment carries the weight of one homework and accompanies a student data sheet which is used to introduce the student lecturer. The student lecturer then develops the lesson and example problem using the assigned reading from the textbook, the lesson objectives, and occasional support from the instructor. The students are encouraged to use multiple mediums to present the topic and solve a pertinent example problem. The students typically use a slide presentation combined with the white board to solve the example problem although no constraints are placed on the student for the lecture. Following brief admin notes and an introduction, the student then lectures for the first 10-15 minutes of the day's lesson. Following the lesson, the class is asked to name what the student lecturer did well and one thing they could have improved - most often, the student rushes the delivery. Frequently, the introduced material is referred back to during the instructor's portion of the lecture and the second voice aids retention of the material to the rest of the class. Benefits from this effort are the introduction of key points that can be referenced during the instructor's portion, preparing and executing a presentation, and instructing their peers. Essentially, the student prepares and presents a familiar topic to an informed and friendly audience.

Introduction:

Previous concept:

The previous instructor for fluid mechanics implemented active learning principles in the course [1]. One aspect within this attempt was to incorporate an unprogrammed student-led lecture of the days lesson. Each student was expected to prepare a quick presentation on the topics of the day and upon arrival at class a name was drawn from a hat and that student would present. A positive aspect of this method was that all of the students prepared a presentation and were thus ready for class. A negative aspect was that with the random assigning, the same student could present multiple times in a semester (or even within the same week). Additionally, as the semester progressed, students would risk being selected and not prepare. The results of the active learning principles incorporated in the class were positive for both the students and instructor and definitely something to continue in the course as it was expected by the incoming students since it was conducted for nine years. While I appreciated the concept of student-led lecture, I wanted to make it my own.

Flipped classroom:

Before accepting this position, I taught a strength of materials course that had moved to a flipped concept using the materials prepared during remote portion of the COVID-19 pandemic [2]. Essentially, the students would watch prepared videos prior to class and then take a quiz, ask questions, and solve problems during the class period. As an instructor, this allowed me to spend time with the students who were struggling with the concepts and quickly monitor those who understood. The motivated students appreciated the structure as they would come with questions and have them quickly answered. The typical passive student did not appreciate the structure as there were expectations of preparation done ahead of class and a quiz at the beginning. What I found most interesting of this attempt, however, was the increase in the student's ownership of the material and their learning through their preparation prior to class.

Technical communication:

Also, while at my previous institution, an emphasis was placed on oral and written (technical) communication in the mechanical engineering curriculum [3]. What was reinforced by this study was that undergraduate students, especially in engineering, benefit from developing and practicing effective communication skills. This importance is why communication is part of the ABET Criterion 3B (3) *an ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to identify and use appropriate technical literature* [4]. An increased emphasis on oral and graphical communication should be considered in every course. The audience (or at least the evaluator) for this style of communication, however, is typically the instructor with limited ability or desire to vary.

Peer instruction:

Combining technical communication with a different audience and intent and the flipped classroom attributes of student ownership of the material led the author to the concept of the student lecturer as a form of peer instruction. Peer instruction as a means of active learning has been researched for a number of years [5-9] with the majority touting the benefits. The engineering community has been slower to accept this path for various reasons to include the classic lecture, sage on the stage, preference by many instructors as well as many students. The complexity of the material often contributes to this mode of presentation as well. Additional concerns are that the students feel anxious or unqualified to present complex material, particularly in technical courses. The faculty may resist peer instruction because of concerns about maintaining control of the material delivery or being unsure of the method's effectiveness. There could be class management challenges – too many students, managing allotted time, fair and even grading, how to ensure quality presentations by the students. Many of these challenges can be offset by structured guidance, clear rubrics, and highlighting the benefits of peer instruction to the class. There are examples of success in a laboratory setting [10] in which a strong positive relationship between preparation and knowledge of the student-teacher was shown as well as higher understanding of students when a classmate explained the concept.

Results and Discussion:

This study represents five semesters (two and a half years) of development and implementation of the programmed student lectures idea and will overview the assignment, my lessons learned, and feedback from the students. For year three, additional quantitative and qualitative feedback was collected and will be discussed.

Year one:

Upon accepting the new position, I saw that the previous instructor had attempted an active learning model for the course and I wanted to discuss this further. After learning about his approach [1], and considering my own experiences as a student and instructor, I modified the requirement while attempted to retain the active learning aspects. Recognizing that I would have hated having to prepare a presentation for each lecture when I was a student, I offered the class an option during the first meeting – would you rather have the previous (unprogrammed) style with names in a hat selected at random or would you rather select a lesson topic and prepare one presentation (programmed)? I included that the expectation for the presentation would be higher if you are programmed to teach and everyone would still be required to outline the material prior to class. Unanimously, the second option, programmed lectures, was selected. That same meeting, the roster was created assigning all 20 students in the course an individual lesson to prepare. There were 27 class meetings for fluid mechanics that semester and only content lessons were assigned – no review lessons, exams or lesson 1 (6 meetings) were assigned as shown in Figure 1.

Lesson	Date	Week	Lesson Topic	Reading	Student Presenter
1	29-Aug	1	Course overview / Introduction	Ch. 1	n/a
2	31-Aug	1	Viscosity of Fluids	Ch. 2	
3	7-Sep	2	Pressure Measurement	Ch. 3	
4	12-Sep	3	Pressure Measurement	Ch. 3	
5	14-Sep	3	Fluid Statics	Ch. 4	
6	19-Sep	4	Fluid Flow	Ch. 6	
7	21-Sep	4	Bernoulli's Equation	Ch. 6	
8	26-Sep	5	Review		n/a
9	28-Sep	5	Exam I		n/a
10	3-Oct	6	Energy Equation	Ch. 7	
11	5-Oct	6	Energy Equation	Ch. 7	
12	10-Oct	7	Reynolds Number, Laminar and Turbulent Flo	Ch. 8	
13	12-Oct	7	Fluid Friction and Energy Loss	Ch. 8	
14	17-Oct	8	Velocity Profiles	Ch. 9	
15	19-Oct	8	Minor Losses	Ch. 10	
16	24-Oct	9	Minor Losses	Ch. 10	
17	26-Oct	9	Pipeline Systems	Ch. 11	
18	31-Oct	10	Review		n/a
19	2-Nov	10	Exam II		n/a
20	7-Nov	11	Pumps	Ch. 13	
21	9-Nov	11	Pumps	Ch. 13	
22	14-Nov	12	Forces Due to Fluids in Motion	Ch. 16	
23	16-Nov	12	Forces Due to Fluids in Motion	Ch. 16	
24	28-Nov	13	External Flow - Drag	Ch. 17	
25	30-Nov	13	External Flow - Lift	Ch. 17	
26	5-Dec	14	CFD / Project	Ch. 9	
27	7-Dec	14	Review		n/a

Figure 1. Sign-up sheet for student lectures overlaid on the course schedule

The presentation is part of the first assignment, “HW0”, which is worth 12.5 points the same as a normal homework assignment. The presentation itself is worth 10 points and the responses to the “student data sheet” is worth 2.5. The student data sheet asked about their hobbies, interests, favorite local restaurant, and favorite quote which would be used to introduce the student lecturer. The quote was on the slide as I introduced them prior to their lecture.

From a student helping review the paper: I always appreciated this part of presentations. It was a good way to break the ice and ease the typically uneasy student into standing before their classmates.

(10 points) Lead an abridged lesson on the day's lesson material at the beginning of class. Have an example problem ready with your presentation from the end-of-chapter pool of problems for the covered material. If you chose to use slides, please send them early for incorporation into the lessons slide deck. You will be graded on content (7.5 points) and delivery (2.5 points). A sign-up sheet will be distributed on lesson 2.

Figure 2. Presentation prompt on HW0 assignment.

At the end of each class, the homework for the next meeting was posted on a slide and contained a few problems from the day's material and the outline of the next lessons reading assignment with the lesson objectives to help focus the outline. The 22 homework assignments were worth 12.5 points each with the lowest two scores dropped at the end of the semester making the total for homework 250 points out of the course total of 1000.

(2.5 points) Review and outline Chapter 6, sections 6.5 - 6.10. If you are presenting, have an example problem ready with your presentation. Below are the lesson objectives to help guide your outline:

1. List the assumptions that allow simplification of the Mechanical Energy Form of Conservation of Energy into the Bernoulli equation.
2. Solve real-world problems using the Bernoulli equation.
3. Define the terms pressure head, elevation head, velocity head, and total head.
4. Define potential energy, kinetic energy, and flow energy as they relate to fluid flow systems.

Figure 3. Example of the assigned outline portion on a homework assignment.

From this prompt, the student was enabled to present the topic as they saw fit – slides, board work, or some combination. Typically, the student made slides for the lesson material that followed the text and addressed the lesson objectives with an example problem pulled from the textbook. The other students were required to write an outline of the assigned reading that was worth a small portion of the overall homework assignment (2.5 points out of 12.5 total points for the homework assignment).

At this point, I want to acknowledge how important a good textbook is to supporting this effort. In the fluid mechanics course, Mott and Untener's Applied Fluid Mechanics textbook [11] was used and the students were very thankful that the text could be used as a comprehensive, stand-alone source.

The outline became a popular portion of the homework assignment with many of the students taking very thorough notes/outline of the reading ahead of class. There were some that wanted to retain them for the lecture as opposed to turning them in with the assignment. To ensure the assignment was completed, they showed their outline prior to the start of the class and I marked it complete on their homework submission allowing the student to retain their outline and continue to take notes.

<u>Fall Feedback</u>: for the fall semester of fluid mechanics (F22), a three-credit hour class that met for 90 minutes on Monday and Wednesday at 8 a.m. the effort was strongly supported by the student and external evaluator feedback.

Students – the vast majority of the feedback from the students was positive on the effort and captured in the end-of-course survey data. The one negative comment pertained more to not liking to present than the effort.

Question 26 What did you like MOST about this course?

I was really skeptical about the student teaching before each class, but it was a great way to get everyone engaged and make us want to learn from each other. I also liked the was the professor presented the class and the way he was engaged with every student.

Despite the fact initially I would have thought I would hate them. The outlines were very beneficial it helped you see the material before the lecture, that way it got easier the second time seeing it.

I'm a big fan of the student led lectures, and I wish more professors would adopt this method. In a way it forces us to take a peek at the material before you reinforce what we've studied in class.

How the lessons that the students had to teach was done. I liked this because the student knew when he had to go and had the chance to sign up for a date that worked best for them or a section that looked interesting to them. This is better than being chosen at random for to teach the lesson.

Instructor made us learn the material three times. Homework, Student Lecture, Instructor lecture. This was quite rad.

External faculty evaluator - The student-led presentation was brief, but obviously required students to review and present a somewhat new topic prior to learning it in class. (The student was required to go through reading assignment and pull out pertinent data, formulas, etc.) As the student was going through the example, (the author) clearly pointed out important aspects, specifically the importance of the +/- sign assigned to velocity values. At one point, he briefly interrupted to clarify where formula values were coming from. When asked about it after class, students stated that they learn quite a bit as a result of this requirement, and it challenges them.

My thoughts – since this was the pilot semester, I tried to be impartial. If the students appreciated the effort, I would keep it going. If not, I would go back to the traditional lecture concept. I was pleasantly surprised with the positive student feedback and the level of effort that the majority of the students put into their presentations. I was also pleased that many students acknowledged the benefit of reading/outlining the material prior to class. With that, I decided to fold it into thermodynamics in the winter semester.

From the student reviewer: (the outline was) very helpful aspect of the courses regardless if students liked doing it or not.

Winter Feedback: using the same approach as fluids for the assignment, HW0, in the winter semester of thermodynamics (W23), a four-credit hour class that met for two hours on Monday and Wednesday at 8 a.m. the effort was not as well received with no positive comments in the course-end-survey and two negative comments.

Students –

Question 25 What suggestions do you have to improve this course?

I appreciated doing the readings ahead of the lecture but I wasn't a fan of the student lecture. I would prefer to have spent the time going over a question or two in the homework.

Question 27 What did you like LEAST about this course?

Honestly, I hated the student lectures. They only really felt valuable if you didn't do the reading.

My thoughts – I was surprised about the comments as the anecdotal feedback during the semester was positive. I did expect more dissenting opinions in this semester as the topic of thermodynamics has more conceptually challenging concepts and the textbook was not as good as the fluid mechanics text. Both of which would make a new learner struggle with creating a presentation for their classmates. There were a number of challenges with this course this semester so I decided to table any changes until I had more data points collected.

Year two:

At the tail end of the previous winter's thermodynamics class I began writing unique homework assignments that were physically distributed with the problems written out as well as the outline and lesson objectives. The student lecturer effort continued with little fanfare and the number of course-end-survey comments matched. During this year, the quick "what did the student lecturer do well?" and "what could be improved?" questions were added following the student's portion of the lecture.

From the student reviewer: Although students generally did not add any revolutionary ideas from these questions, I certainly think they are worth the little bit of time. Hearing where you excelled and where you fell short felt nearly as important as the presentation itself.

Fall Feedback: for the fall semester of fluid mechanics (F23), nothing changed as far as credit hour, day, or time.

Students – there were no complaints regarding the effort as it was part of the course at this point and few mentioned the effort in the free text comments.

Question 26 What did you like MOST about this course?

I enjoyed most of the homework problems, I liked balancing all the different variables that were involved in the problems. This made for difficult problems at first but forced me to sit down and understand the equations and how they relate to each other far better. I thought peer presenting was also a good touch because many students including myself could use more presentation skills

My thoughts – this was the third semester of the effort and was an accepted part of the class. The incoming students did not need convincing and seemed to enjoy presenting. The students were also reluctant to give real-time (negative) feedback to the student and I would often ask their buddy to be the "bearer of bad news" and give an area to improve. As the semester moved along, this was more readily given and generally appreciated by the presenter.

<u>Winter Feedback</u>: for the winter semester of thermodynamics (W24) nothing changed as far as credit hour, day, or time; the textbook remained the same as well.

Students – this semester saw much more positive feedback and was generally an agreeable cohort.

Question 26 What did you like MOST about this course?

That (the author) is the professor. Also having students present the material is nice to have them help understand the material. Also taking a trip to the steam plant was cool to see what we were learning applied in real life.

The almost flip class room where we would learn at home and do problems in school

Student presentations were good for highlighting key points on new topics.

My thoughts – I was hesitant to include the student presentations in this course this semester after the negative reaction in the year one thermodynamics course. However, I was glad that I did. This group of students really seemed to understand the intent and would try to out-do each other with their presentations.

Year three:

Following the success of year two, I decided this was a pretty good idea and I should formalize the effort and take it to ASEE as a conference proceeding. During the fall semester fluid mechanics course (F24), I announced early on that I intended to publish the results of this effort; this seemed to energized the class. I was also more deliberate in collecting their feedback and will continue to do so in the winter semester's thermodynamics course.

The students were given two opportunities to provide feedback: (1) as free text response on the last homework assignment for a typical problem point value; and (2) as an in-class survey on the last class period with a Likert scale. The Likert scale was broken into three frames of mind – answer as a member of class; answer as the presenter; and give overall impressions.

Table 1. Year three fall semester survey.

	Question:	SD 5	D 4	N 3	A 2	SA 1	Weighted Score
1	As a member of the class (not presenting):						
1.1	I read the material and outlined the reading assignment before the lesson	0	2	0	6	10	1.67
1.2	My understanding of the material increased as a result of the student lecturer	0	1	2	10	5	1.94
1.3	The sample problem aided in my understanding of the lesson material	0	0	2	9	7	1.72
2	As the presenter:						
2.1	My understanding of the material increased as a result of preparing and presenting	0	0	0	2	16	1.11
2.2	I appreciated the discussion following the lecture on what went well / what could be improved	0	0	2	7	9	1.61
2.3	My confidence in my ability to present to a technical audience increased	0	0	1	7	10	1.50
3	Overall:						
3.1	The overall lesson was enhanced by the student lecturer	0	1	1	10	6	1.83
3.2	The student lecturer idea should continue in the course	0	1	0	3	14	1.33

Table 1 shows the survey results taken at the end of the semester and has 18 of the 20 students in the class responding. Lower is better on the scale (1 for strongly agree and 5 for strongly disagree) with the overall weighted score shown in the last column on the right. The first block of questions was intended to baseline the student's participation in the effort (did you do the outline?) as well as how did the student receive the student lecturer. Question 1.1 shows that the bulk of the students did the reading/outline before the lesson (16 of 18 responses were agree or strongly agree) with two admitting to not doing the outlines. Since each homework was collected and graded, this was not new information. Question 1.2 was on student understanding increasing as a result of the student lecturer and was the worst overall score (1.94 out of 5) and shows again in the free-text comments with criticisms on other student preparation/effort. Even with the poorer score, 15 of 18 still agreed/strongly agreed that their understanding increased. Question 1.3 highlights that students always like seeing an example problem even when done by their peers with a slightly better score than question 1.2.

The second block of questions asks the responder to consider the student lecturer idea as the actual presenter. Question 2.1 really highlights the benefit of this effort – all students acknowledged preparing and presenting increased their understanding of the material (18 of 18 agree or strongly agree). Question 2.2 asked whether the quick discussion following the presentation on what went well / what could be improved was appreciated. The results were generally good, but this question was really for me to consider whether I should include a more formal peer-evaluation aspect to the student lecture. In other courses I teach, the students have the opportunity to provide comments on the delivery and the content of their peer's presentation. Question 2.3 asked whether the student's confidence in presenting increased and 17 of 18 agreed or strongly agreed.

The third block of questions asked about the overall student lecturer idea. Question 3.1 was probably too similar to question 1.2 and had a similar breakdown of scores. Question 3.2, however, was extremely positive with 14 of 18 strongly agreeing (17 of 18 agree/strongly agree) with the continuation of the student lecturer idea for the course and one of the two negative responders even moved into the agree or strongly agree pool!

As part of this survey, free text comments were included and asked for improvements and additional comments. For brevity, similar comments were removed and the remaining are grouped into positive and constructive/negative below:

<u>Positive:</u>

I liked it

Helps give a second view of the material

I enjoyed it quite a bit. Nice to start the hard lessons with a peer's understanding of the topic as an ease into the lesson

At first, I hated the idea, but as the class went on I realized how much it helped me learn as a student, the student lecture perspective helped give a new insight or way to think about it

Big fan; teaching a topic is the best way to learn it

I like the idea for increased engagement and more time spent on each concept

The student lecturer allowed me to have a base of knowledge about what the lesson was going to be about before the more technical information presented by the professor

I like the change in style of presentations; haven't done one like this in other classes

It works well when the student prepares properly

Presenting was a good way to switch up the engagement while making sure all the notes are covered in class. It is also important to practice presenting.

It forced more engagement with the course content. In order to make a presentation about a lesson, it is essential to understand what was read. This forced me to read for comprehension and not just to write words on a paper to turn in for points. I also really enjoyed making the presentation. It allowed me to interact with the textbook from a different perspective.

I feel that I had a deeper understanding of the material that I presented because I wanted to make sure everything I was saying was correct in front of the class.

I thought it was unique and was a smart way to teach it to the class. I think making all the students present to the class forces us to listen and acknowledge what the students are teaching so that we can prepare ourselves for when it's our turn.

I liked the feedback from you and students, plus the opportunity to practice presenting.

I found that I became very good at the portion that I presented to the class because of the extra time I spent researching and creating the presentation.

I enjoyed the personal quotes to start and the questionnaire to get people familiar with some things about their fellow classmate.

I thoroughly enjoyed student lectures as a "warm up" and a nice sort of introduction/pre-lesson to get an early grasp of the concept before more depth as well as the "fresh" perspective from the student.

Watching students do example problems when they (usually) are not entirely confident in themselves, if nothing else, can be a boost in morale. It is comforting to know you are not alone when you struggle with difficult concepts. On the flip side, seeing peers successfully teach complex topics was inspiring and made me feel like I could also master the material. It is nice to see fellow students get out of their shell and do a presentation because most of the time there are only a few students answering questions and being involved in class.

<u>Constructive / Negative:</u>

More structure for student led lectures

Possibly make it worth more points so it is taken more seriously

I think it would be helpful for everyone in the course if you were to pick a specific sample problem for the student lecturer to do

Groups/pairs present longer, more complex ideas together

It is very apparent when someone doesn't care about the presentation. When this happens, I feel that I don't gain any additional benefits

I felt student lectures often left me wishing the instructor trained to teach this subject would have taught the lesson. Some students grip on the content they present impacted my ability to learn the material

Students might want to know that is what the "tell me about yourself" form is for

My thoughts – I had early student buy-in which was great. The students really embraced the opportunity and were questioning their peers during their presentation, practicing, and including me in their preparation. Getting this much feedback has definitely helped shape the next iteration of the student lecturer idea for this coming winter semester.

<u>Summary of Findings:</u>

1. Some don't like it. Each semester has seen one or two who just don't like the idea of student lectures – they could prefer the passive style of typical college lecture; they could hate the idea of presenting; they could disagree with the allocation of time towards someone other than the instructor; and/or something else not mentioned in their comments and feedback.

2. Some appreciate the effort and/or like a "unique" or "different" approach. These students like to be a part of something new; may appreciate the unique approach; and/or may like the instructor and want to see the efforts rewarded. This appreciation may overvalue the attempt rather than critically evaluate the actual idea.

3. Some like the idea but have suggestions for the implementation. Some of the suggestions included make it worth more points; include a peer-review the presentations; provide more structure for the presentation or for the outline; and/or make the student do an instructor selected problem.

4. Some like the idea as it is. These students saw the student lecturer idea as it was intended to be – a low threat opportunity to prepare and present technical information to an informed audience of their peers.

<u>Final Grade Comparison:</u>

The final grade distribution for fluid mechanics is shown in Figure 4 and highlights the previous version (F21) and the three years of the student lecturer idea (F22, F23, and F24). Similarly, the final grade distribution for thermodynamics is shown in Figure 5 and has the previous version (W22) and the two years of the student lecturer idea (W23 and W24).

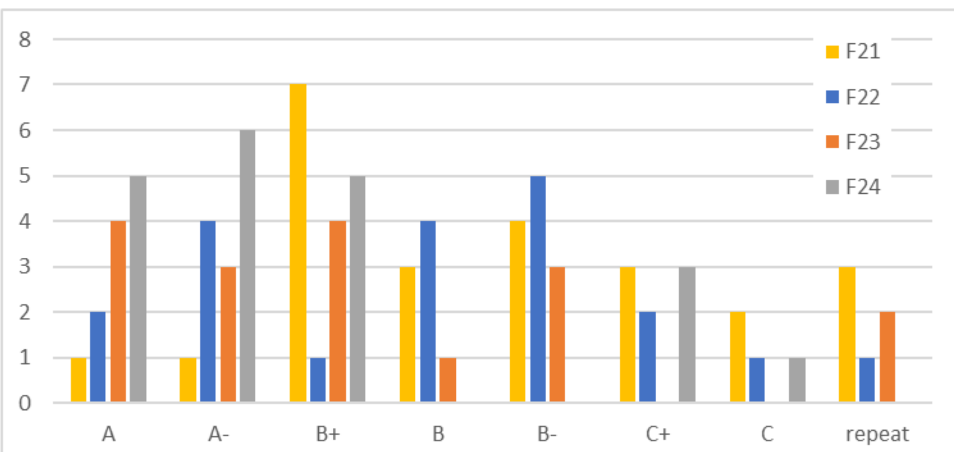

Figure 4. Final grade distribution for Fluid Mechanics courses over four-year period. F21 was under the previous structure and F22 and beyond were using the student lecturer concept.

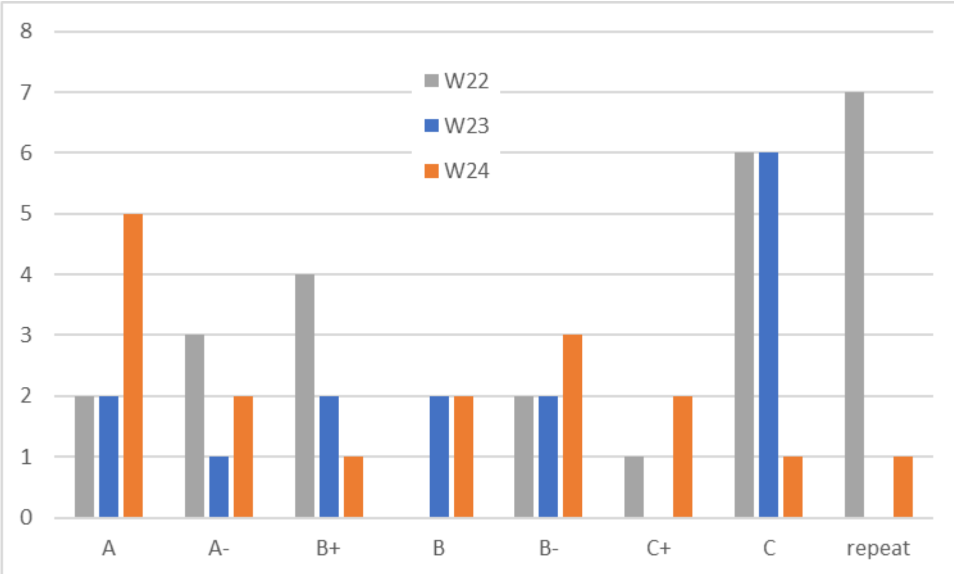

Figure 5. Final grade distribution for Thermodynamics courses over three-year period. W22 was under the previous structure and W23 and W24 were using the student lecturer concept.

Recognizing that many factors shape the final course grade beyond just this one concept, no definitive statements will be made when looking over this data. There was a change in instructor from F21 and W22 to the current instructor (F22 and beyond). Interestingly for the previous instructor, the fluid mechanics course had the active learning component and saw better overall grades than the thermodynamics course without that component. Some interesting trends for the evaluated period (F22 and beyond) are that the number of A's has increased over the trial period and the number of C's and below has decreased each term. Again, there are many additional factors to include beyond the student lecturer idea, but the general structure of the course and material covered have not changed.

Course objectives:

The course outcomes for MET 420 (Fluid Mechanics) are listed below and the comparison of the number of students enrolled in the course and the number meeting the department standard of 72% or higher in the evaluated assignments.

1. Apply static fluid principles to determine pressure variation within a fluid and the forces exerted on submerged surfaces
2. Analyze fluid behavior associated with internal and external flow
3. Apply the general energy equation to a fluid flow system
4. Analyze and interpret provided and calculated results; communicate these results to a general scientific audience

Table 2. Number of students meeting the course objectives for MET 420 Fluid Mechanics

MET 420	Fall 2022		Fall 2023		Fall 2024	
Outcome	#	>72%	#	>72%	#	>72%
1	20	20	17	15	19	19
2	20	20	17	15	19	19
3	20	20	17	15	19	19
4	20	19	17	15	19	19

The course outcomes for MET 410 (Thermodynamics) are listed below and the comparison of the number of students enrolled in the course and the number meeting the department standard of 72% or higher in the evaluated assignments.

1. Determine the fundamental thermodynamic and physical properties of relevant solid materials, static fluids, and fluid flows, to include ideal gases, liquids, steam, refrigerants, and air-water vapor mixtures.
2. Apply Conservation of Mass and the 1st Law of Thermodynamics to Closed Systems and Control Volumes.
3. Apply principles of the 2nd Law of Thermodynamics to analyze performance limits on Closed Systems and Control Volumes.
4. Analyze and design thermodynamic systems using Conservation of Mass, Conservation of Energy, the 2nd Law of Thermodynamics, and cycle performance limits.

Table 3. Number of students meeting the course objectives for MET 410 Thermodynamics

MET 410	Winter 2023		Winter 2024	
Outcome	#	>72%	#	>72%
1	15	15	17	16
2	15	15	17	16
3	15	15	17	16
4	15	15	17	16

Both Table 2 and 3 show that the students are meeting the course objectives at a high level. As with the discussion on including the final grades, there are more factors than just the student lecturer concept that will influence student success. However, also like the final grades show, the student lecture idea is a significant part of the course and the students are very successful.

Conclusion

The student lecturer concept took aspects of the flipped classroom like preparation and ownership of the material and technical communication like preparing and conducting presentations and modified the intent and audience into a peer instruction opportunity for engineering students. The vast majority of the quantitative and qualitative feedback from the students indicates that this has been a success and something they want to continue in subsequent course offerings. Other performance metrics like meeting course objectives and final grades show positive correlation with the structure of the course including the student lecturer concept and student success.

Next phase: folding in many of these recommendations for the upcoming winter semester of thermodynamics (W25), a student note packet has been developed and contains each lesson's objectives, reading assignment, and a sample of problems that are external to the textbook for the student lecturer to solve. This will allow the student to begin preparation well in advance as well as solve a unique problem to the class that the instructor selected. The concern now is being overly prescriptive to the student lecturer and stifling their creativity. A low-threat peer evaluation system will also be implemented to provide additional feedback to the lecturer. This will be slips of paper with the presenter's name, blocks for grades of delivery and content, and additional comments on the lecture. Additionally, I will have more students than lectures this coming semester and will offer the opportunity to work as pairs on the more complex material.

Recommendations for others wishing to attempt this idea: I have approximately 20 content lessons per semester which maps to 20 students lecturing. If you have larger classes, I would recommend offering pairs as an option. Initially pairing for the more complex lessons and then pairs for each lesson for a class size of up to 40 students based on the 20 content lessons estimate. Beyond that, I wouldn't recommend moving to groups of three or more as this is too small of an assignment for three. For larger classes, or for exploring with the idea, another option would be to ask for volunteers with the opportunity for bonus points or a potential grade replacement on a low scoring homework.

References:

[1] M. Martin, "Implementing Active Learning Principles in an Engineering Technology Fluid Mechanics Course," *2013 ASEE Annual Conference and Exposition, Atlanta, GA, USA, 23-26 June 2013.*

[2] K.F. Mcmullen, D. Carlson, B.G. Davis, J. Barron, B.E. Barry, J.C. Bruhl, "Comparison of Four Flipped Classroom Implementations in a Civil Engineering Curriculum during the COVID-10 Pandemic," *2022 ASEE Annual Conference and Exposition, Minneapolis, MN, USA, 26-29 June 2022.*

[3] Norberg, S., Ashcraft, T., Van Poppel, B., "Integrating Technical Communication in the Mechanical Engineering Curriculum", *70th Annual Meeting of the APS Division of Fluid Dynamics, Denver, CO, 19-21 November 2017.*

[4] ABET. “Criteria for Accrediting Engineering Technology Programs, 2022-2023”. Accessed 2025, URL https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-technology-programs-2022-2023/

[5] K.L. Benè and G. Bergus. "When learners become teachers: a review of peer teaching in medical student education." *Family medicine*, vol. 46.10, pp. 783-787, 2014.

[6] D. Boud, R. Cohen, and J. Sampson. "Peer learning and assessment." *Assessment & evaluation in higher education*, vol. 24.4, pp. 413-426, 1999.

[7] Felder, R., and Silverman, L. K., “Learning and Teaching Styles in Engineering Education,” *Eng. Educ*., vol. 78(7), pp. 674-681, 1988.

[8] S. Hartikainen, H. Rintala, L. Pylväs, and P. Nokelainen, “The Concept of Active Learning and the Measurement of Learning Outcomes: A Review of Research in Engineering Higher Education,” *Education Sciences*, vol. 9, no. 4, p. 276, Nov. 2019, doi: https://doi.org/10.3390/educsci9040276.

[9] S. Ramaswamy, I. Harris, and U. Tschirner. "Student peer teaching: An innovative approach to instruction in science and engineering education." *Journal of science education and technology*, vol. 10, pp. 165-171, 2001.

[10] Constantin Cătălin Dosoftei and L. Alexa, “Students’ perception of peer teaching in engineering education: a mixed–method case study,” *Humanities and Social Sciences Communications*, vol. 11, no. 1, Jun. 2024, doi: https://doi.org/10.1057/s41599-024-03349-y.

[11] R.L. Mott and J.A. Untener, *Applied fluid mechanics.* Boston: Pearson Education, Inc, 2022.