The Utilization of Case Study Presentations in Fluid-Thermo Courses in Manufacturing Engineering Technology

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Abstract

Engineering technology programs commonly integrate fluid-thermo related courses yet encounter certain challenges. First, engineering technology classes are required to cover a wide range of topics, leaving limited time for fluid-thermo related courses. Second, the programs prioritize practical applications, whereas traditional fluid-thermo classes involve complex equations. Third, while strong in practical skills, engineering technology students may struggle with advanced mathematics. Despite these challenges, numerous fluid-thermo related topics have significant value for engineering technology students such as the first law of thermodynamics, thermal conductivity, thermal expansion, drag force, hydrostatics, and psychrometric charts, etc.

Therefore, it is essential to adopt a distinct approach when designing fluid-thermo related courses in engineering technology programs, distinguishing them from courses offered in other engineering programs: i) emphasizing practical applications to ensure relevant and useful content for real-world scenarios. ii) prioritizing essential fundamental concepts and key principles of significant importance. iii) incorporating necessary equations and calculus while minimizing complexity.

In this light, the utilization of end-of-semester case study presentations in fluid-thermo courses offers several benefits. Throughout the semester, instructors prioritize applied fluid-thermo concepts. In addition, it allows students to study deeper into topics of interest, including concepts, equations, applications, and emerging technologies. Moreover, students gain valuable insights from peers' presentations while receiving feedback and detailed explanations from instructors during Q&A sessions. Additionally, these presentations inspire the development of new labs for continuous course improvement in subsequent semesters. The survey and course evaluations results also show the use of case study presentations stimulates student interest and promote active engagement in class.

Introduction

Fluid-thermo classes are integrated into engineering technology programs' curriculum, yet their incorporation presents challenges for several reasons. Engineering technology programs include diverse topics, so it results in limited time for fluid-thermo courses despite their significance. In addition, engineering programs emphasize practical applications, whereas traditional fluid-thermo classes involve complicated equations and calculus. This calculus contents might pose difficulties for engineering technology students, despite their strength in practical and hands-on skills.

Researchers have explored the potential for distinctive and innovate teaching pedagogies in fluid-thermo related courses within engineering technology programs. A study by Ayala and Popescu [1] showed the benefits of a flipped classroom format in fluid mechanics classes for engineering technology students. Additionally, Martin [2] implemented active learning principles into an engineering technology fluid mechanics course, resulting in higher exam scores and student benefits. Choudhury and Rodriguez [3] demonstrated a reformed fluid mechanics curriculum with a multi-modal teaching drives a better learning experience for new generation of students. Mulop, Yusof, and Tasir [4] reviewed and analyzed various approaches to support students' learning of thermodynamics considering factors such as the learning system, effectiveness, skills development, and feedback from students. However, research focused on teaching pedagogy for fluid-thermo courses in the context of the manufacturing engineering technology programs remains currently limited.

Several studies have explored the implementation of case study presentations across various courses. Shallcross [5] demonstrated the successful utilization of case study presentations in a chemical engineering class. Similarly, Field [6] highlighted the effective use of case study presentations in biology courses. In addition, Field [7] made an effort to transform case study presentations into an independent research project, after recognizing the potential demonstrated in senior students' case study presentations. Nevertheless, there is currently no published work or conference paper pertaining to the implementation of case study presentations within the context of engineering or engineering technology programs.

Fluid Thermo Class in Manufacturing Engineering Technology Curriculum

Figure 1 illustrates a comparison between fluid-thermo classes in the manufacturing engineering technology program (above) and those in the mechanical engineering program (below) as examples. Given the extensive array of manufacturing-related courses that needs to be covered, the program typically includes only one thermos/fluid class, Applied Thermodynamics and Fluid Dynamics. This course's content is typically distributed across three distinct classes in the mechanical engineering program: i) thermodynamics, ii) fluid mechanics, and iii) heat transfer.

In addition, considering the potential inclusion of other advanced technical elective courses, there may be even more than three fluid-thermo classes in the mechanical engineering program [8]. Consequently, consolidating the content into a single class within the manufacturing engineering program poses a significant challenge.

Semester 3 — 14 cr	Semester 4 — 15 cr
GENG 102 Engg Problem Solving -3	ETS 183 Tech & Third World -3 (LE-5,8, D)
ETS 260 Environmental Studies -3 (LE-10)	MFET 242 Thermo/Fluids -3
MFET 240 Metrology -2	MFET 243 Strength of Materials -3
MFET 241 Statics/Dynamics -3	STAT 239 Statistics for Physical Sciences -3
MFET 345 Manufacturing Processes -3	Technical Elective -3
Semester 5 — 15 cr	**Semester 6 — 15 cr**
Liberal Ed Elective -3 (LE-2)	MFET 340 Continuous Improvement -3
MFET 314 Design for Manufacturability -3	MFET 348 Plastics Manufacturing -3
MFET 343 Computer Integrated Mfg -3	GENG 360 Engineering Economics -2
ECON 205 or 206 -3 (LE-5)	GENG 380 Engineering Communication -2
Technical Elective -3	Technical Elective -3
	Technical Elective -2
Semester 7 — 15 cr	**Semester 8 — 15 cr**
Liberal Ed Elective -3 (LE-6, D)	Liberal Ed Elective -3 (LE-6,7, D)
MFET 440 Production Systems Control -3	MFET 446 or 447 Mfg Concepts -3
MFET 448 Composite Materials -3	MFET 471 Capstone -3
MFET 470 Capstone -3	Technical Elective -3
Technical Elective -3	Technical Elective -3

Sophomore Year

Fall Semester

- ◊ Math 2374 Multivariable Calculus *(1372)* [4cr]
- ◊ AEM 2021 Statics & Dynamics *(Phys 1301W, &Math 2374)* [4cr]
- ◊ MatS 2001 Intro to Engineering Materials *(CSE, Chem 1061/65, Math 1372, Phys 1301W)* [3cr]
- MatS 2002 Engineering Materials Lab *(&MatS 2001, ME majors only)* [1cr]
- **ME 2011 Intro to Engineering** *(CSE pre-major)* [4cr]

Spring Semester

- Math 2373 Linear Algebra & Differential Equations *(1372)* [4cr]
- AEM 3031 Deformable Body Mechanics *(2021, Math 2374, &Math 2373)* [3cr]
- ◊ ME 3331 Thermodynamics *(Chem 1061/65, Phys 1301W)* [3cr]
- CHOOSE ONE:
  - ME 2021 Intro to Prog & Computations (&*Math 1372*) [4cr]
  - CSci 1113 Intro to C/C++ *(Math 1371)* [4cr]
  - EE 1301 Intro to Computing Systems [4cr]
- Liberal Education course [3 or 4cr]

Junior Year

Fall Semester

- ME 3221 Fundamentals of Design & Manufacturing *(UD, 2011, AEM 3031, MatS 2001)* [4cr]
- ME 3332 Fluid Mechanics *(UD, 3331, Math 2373)* [3cr]
- IE 3521 Stats, Quality, & Reliability *(Math 1372)* [4cr]
- EE 3005 Fundamentals of EE *(Phys 1302W, Math 2373)* [4cr]
- EE 3006 Fundamentals of EE Lab *(&3005)* [1cr]

Spring Semester

- ME 3222 Mechanisms & Machine Design (*UD, &3221, ME 2021 or CSci 1113 or EE 1301*) [4cr]
- ME 3333 Heat Transfer *(UD, 3332)* [3cr]
- ME 3281 System Dynamics & Control *(UD, AEM 2021, Math 2373)* [4cr]
- ME 4031W Basic Measurements Lab *(UD, 3331, IE 3521)* [4cr]

Fig. 1. Fluid-thermo classes in manufacturing engineering technology program (Above: from St. Cloud State University) and fluid-thermo classes in mechanical engineering program (Below: from University of Minnesota [8]).

Table 1. Contents relevant to fluid-thermo in other courses in the manufacturing engineering technology program.

Class #	Class Name	Contents Relevant to Fluid-thermo
MFET243	Strength of Materials	Thermal properties, thermal resistance, design for creep, working hardening
MFET343	Computer Integrated Manufacturing	Coolants and heat transfer, internal energy, thermal conductivity, Reynolds number, drag force, Bernouli's principle, The first law of thermodynamics
MFET345	Manufacturing Processes	Heat treatment (quenching, annealing, normalizing), Center punch project, thermal radiation
MFET348	Plastics Manufacturing	Glass transition temperature, injection molding, blow molding, compression molding, thermal expansion of plastics, thermal resistance, dynamic viscosity and melt index,
MFET430	Mass Production	Refrigeration cycle and power cycle
MFET446	Manufacturing Concepts	Ergonomics and psychometric charts (comfortable humidity levels in facilities), barometer pressure
MFET448	Applications of Composite Materials	Carbon fiber/fiber glass injection molding simulation, Thermal conductivity, thermal resistance, gage pressure in Resin Transfer Molding (RTM), hydrostatics
MFET470 MFET471	Senior Capstone Projects	Thermal properties, thermal expansion, humidity, Thermal expansion, the first law of thermodynamics, mass flow rate, drag force, streamlined design

Even when the fluid-thermo content is consolidated into one class, its significance remains essential for students in manufacturing engineering technology. Table 1 demonstrates the integration of fluid-thermo concepts across various program courses. Figure 2 illustrates how these concepts benefit classes, exemplified by the center punch project in Manufacturing Processes (MFET345). This project primarily requires students to use lathe machines, but also involves post-processing like quenching and normalizing, all of which benefit from knowledge gained in Applied Thermodynamics and Fluid Mechanics (MFET242): convection, thermal radiation, heat transfer coefficients, and thermal conductivity. Hence, the importance of fluid-thermo-related content cannot be understated for students in manufacturing engineering technology.

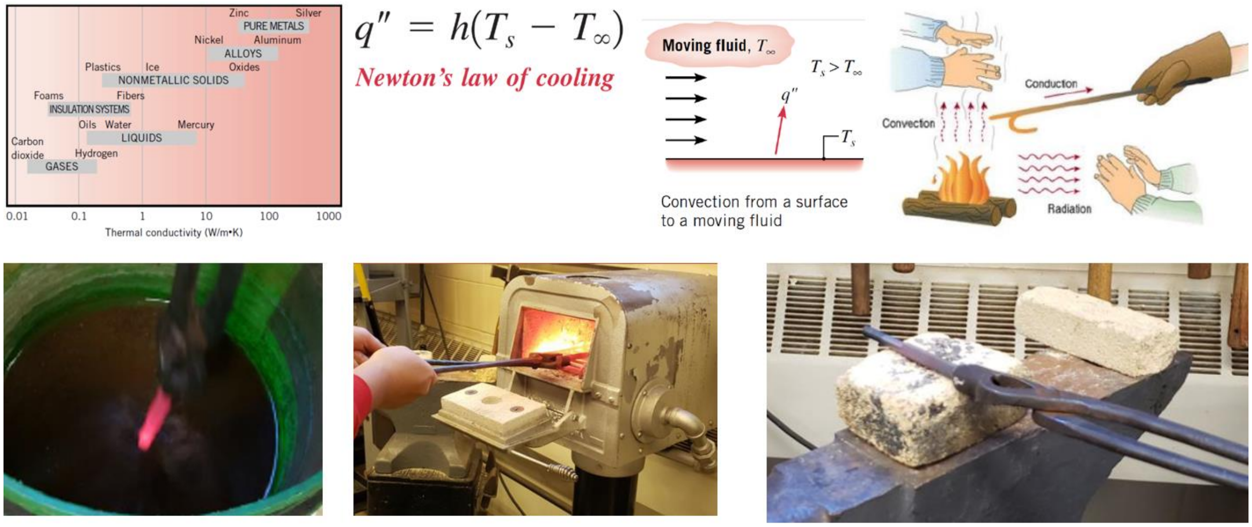


Fig. 2. Fluid-thermo related contents in the manufacturing engineering technology program courses: Manufacturing Processes (MFET345).

Case Study Presentations Format in Class

Case Study Presentations are scheduled at the end of the semester for Applied Thermodynamics and Fluid Mechanics (MFET242) course. For the presentation, students are given the freedom to select topics related to thermodynamics, heat transfer, and fluid mechanics, which may include emerging technologies. Each presentation is expected to cover the following aspects:

i) Background information on the chosen topic
ii) Fundamental concepts related to the topic
iii) Practical applications of the topic
iv) The impact of the topic on people's lives

The first two elements involve the knowledge and comprehension levels of Bloom's Taxonomy of Cognitive Development [9], while elements iii and iv pertain to the application, analysis, and evaluation levels of that. Presentations are announced two weeks prior to the presentation dates, affording students ample time to study deeper into their selected topics and prepare engage presentations for the peers.

Each presentation is allocated approximately 10 minutes, including Q&A session. To encourage active participation and engagement, two strategies have been implemented. First, each student is required to ask at least two questions during the presentation period to receive full participations points. Second, peer evaluations are conducted during the Q&A sessions. These additional measures serve to enhance students' focus and involvement during the presentations. Figure 3 shows peer evaluation utilized in the case study presentations.

The utilization of peer evaluations during class presentations is widely acknowledged as beneficial. Research conducted by Girard, Pinar, and Trapp [10] demonstrated that students can benefit from peer evaluations, leading to increased engagement and enhanced listening skills during presentations.

Peer Evaluation: Case Study Presentation

Presenter ________________________

Evaluator Name (Your Name) _________________________

Time Management

poor	1	2	3	4	5	6	7	excellent

Clarity of the Message

poor	1	2	3	4	5	6	7	excellent

Effectiveness of the Delivery (presenters and slides: graphs, images)

Poor	1	2	3	4	5	6	7	excellent

Effort to Prepare for the Presentation

poor	1	2	3	4	5	6	7	excellent

What do you think of the recommendation?

poor	1	2	3	4	5	6	7	excellent

Choice of Topic (circle one) Could be better Adequate Very Good

Any comments? (Did you find it interesting? Did you learn anything from the presentation?)

Fig. 3. Peer evaluation utilized in case study presentations.

Initial Implementation of Case Study Presentations and Changes

When the case study presentations were initially introduced in fall 2017, students' presentations were spread throughout the semester. The presentations occur at the beginning of the class, typically within the first 15 minutes. This format has its advantages. The presentations serve as a class refresher and encourage students to contemplate various applications during each session. Figure 4 displays the initial schedule that was implemented.

However, this approach encounters several challenges. First, students who presented early in the semester had limited opportunities to explore a variety of fluid-thermo related topics, resulting in presentations that were often too broad and of suboptimal quality. In addition, evaluation process would not be equitable because students who presented later in the semester had the advantage of preparing their presentations based on what they had observed earlier in the semester. Second, some students ambitiously researched topics that had not yet been covered in the course, leaving their other students in the class without the background knowledge to fully comprehend the presentations. Consequently, even with the significant time invested by the presenting students, the presentations were not highly effective on both presenters and other students in the class. Thirdly, the format did not accommodate students' absences well and other unforeseen circumstances with flexibility. Taking these challenges into account, it was decided to schedule the presentations at the end of the semester, after all required course content had been covered.

ETS 242: Case Study Presentation Schedule

Date	Day	Student Name
19-Sep	Tuesday	Student A
21-Sep	Thursday	Student B
3-Oct	Tuesday	Student C
5-Oct	Thursday	Student D
12-Oct	Thursday	Student E
17-Oct	Tuesday	Student F
19-Oct	Thursday	Student G
26-Oct	Thursday	Student H
31-Oct	Tuesday	Student I
2-Nov	Thursday	Student J
7-Nov	Tuesday	Student K
9-Nov	Thursday	Student L
21-Nov	Tuesday	Student M
28-Nov	Tuesday	Student N
30-Nov	Thursday	Student O
5-Dec	Tuesday	Student P

Fig. 4. Initial case study presentations schedule in fall 2017.

Examples of Case Study Presentations

Figures 5-8 showcase some notable examples of students' case study presentations. Figure 5, titled "Fluid Mechanics and Bicycles," illustrates one students' presentation. This in-depth and informative presentation involves the concept of drag force in the context of bicycles applications. It provides a comprehensive understanding of fundamental concepts and practical applications. Figure 6, "Deep See Exploration," shows another student's presentation that inspired classmates to explore hydrostatics more deeply, which were discussed in class during the semester. The presentation not only reinforced the subject matter but also fostered productive discussions during the Q&A sessions.

Figures 7 illustrates the practical application of fluid-thermo concepts in manufacturing processes. During this presentation, the student highlighted the challenges associated with machining Titanium, emphasizing that a significant portion of the heat generated is transferred to the tool. It results in rapid tool degradation and inconsistent cutting conditions, thus requires high-pressure coolant delivery. Such presentations encompass various aspects of thermodynamics, fluid mechanics, and heat transfer. In Figure 8, another student's presentation focused on the phase change material (PCM). The student delivered a comprehensive explanation of PCB functions, fundamental concepts like latent heat, various applications, and their impact. It facilitated a more in-depth discussion after the presentation, connecting previous covered class topics with current trends in PCM research, particularly in electronics products like smartphones.

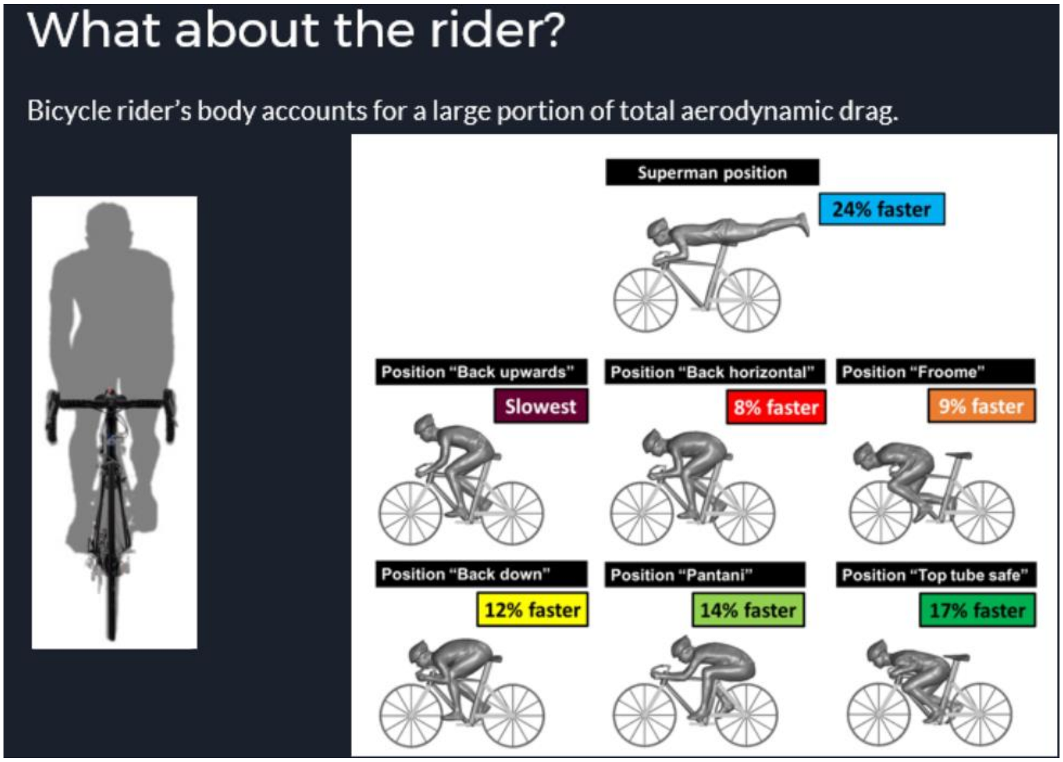


Fig. 5. A student's example of case study presentation: "Fluid Mechanics and Bicycles."

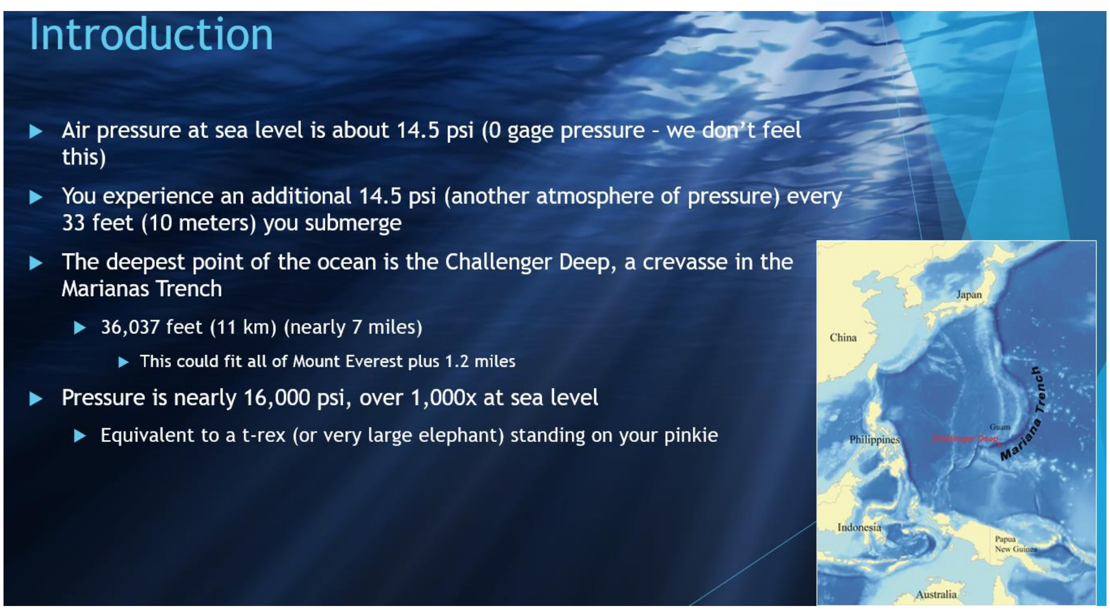


Fig. 6. A student's example of case study presentation: "Deep Sea Exploration."

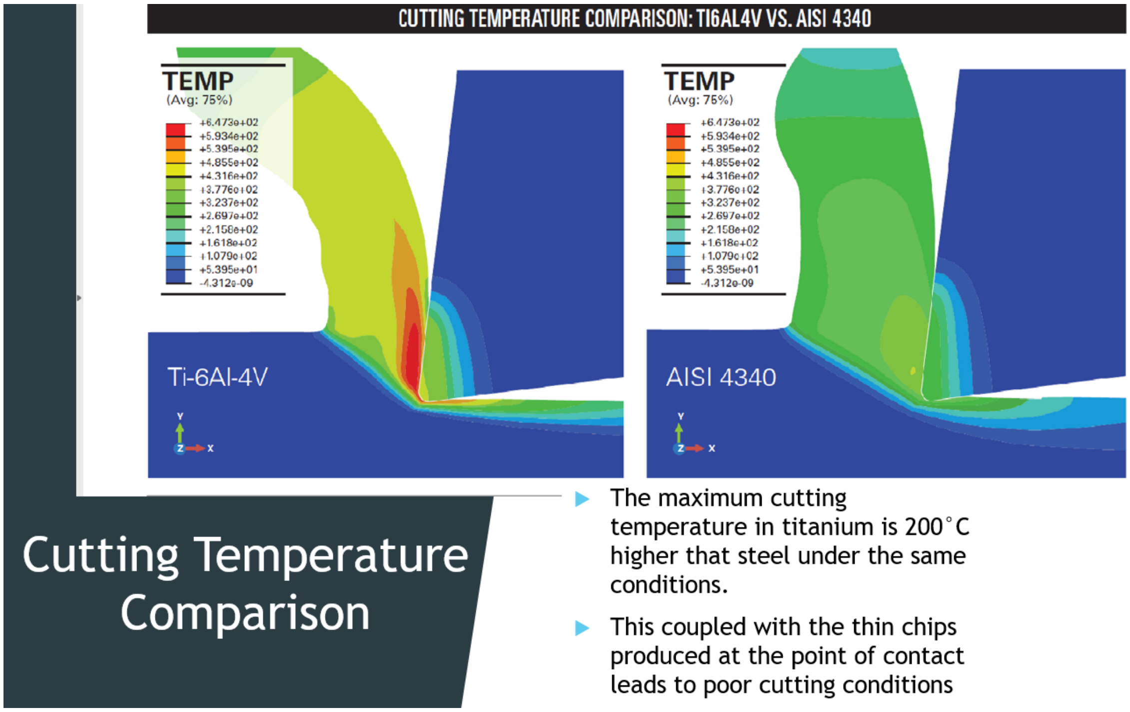
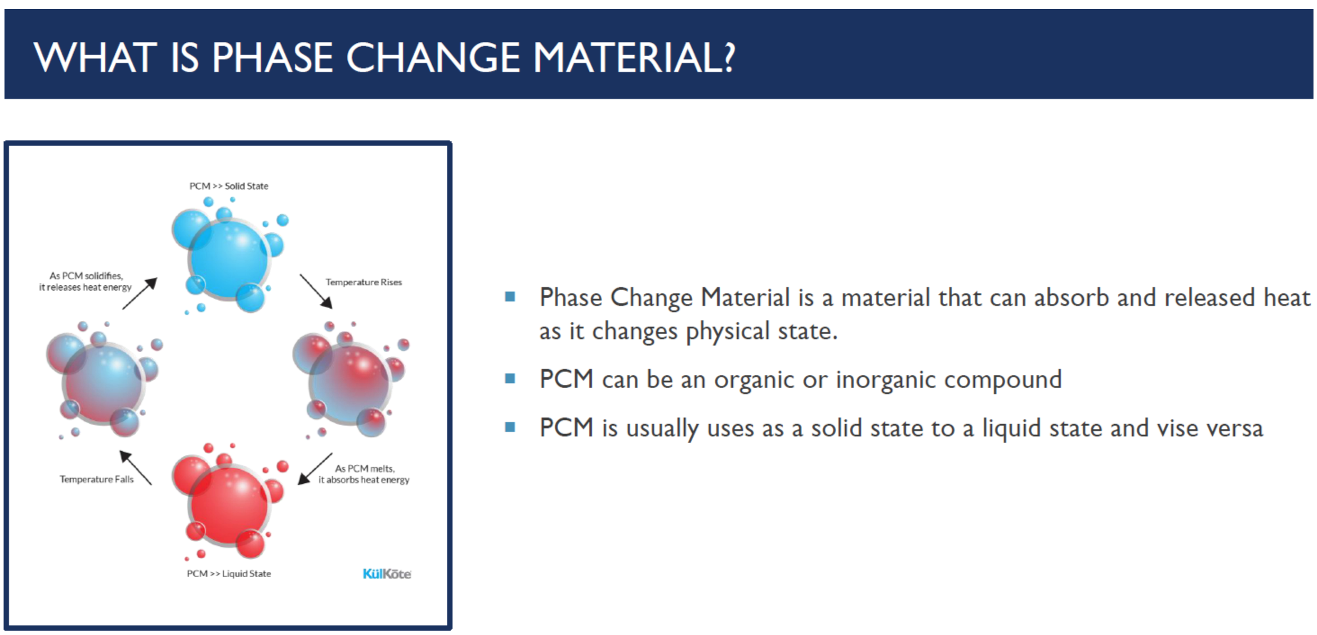


Fig. 7. A student's example of case study presentation: "Machining Titanium."



Fig, 8. A student's example of case study presentation: "Phase Change Material (PCM)."

Benefits of Case Study Presentations

Several benefits of case study presentation have been identified:

1) *Instructor's practical focus*: The presentations encourage instructors to emphasize practical aspects. Instructors are aware of the upcoming case study presentations at the end of the semester, which shapes their mindset to consistently emphasize the practical applications of concepts throughout the semester.
2) *Emphasis on fundamentals*: Fundamental concepts cannot be overlooked, as they provide the essential building blocks for a comprehensive understanding of case study presentations. A strong foundation in fluid-thermo knowledge is imperative for students to engage effectively with these presentations as well.
3) *Deeper learning opportunities*: Students can explore thermos-fluid topics in greater depth. Since the topics align with their interests, students are highly motivated to thoroughly prepare for their presentations.
4) *Peer learning*: Students learn from their peers' presentations, fostering a collaborative learning environment as well.
5) *Active engagement*: The requirement for each student to ask at least two questions during presentations, along with peer evaluation, promotes active participation.

Benefits of Case Study Presentations for Other Classes: Injection Molding Simulation Projects in Applications of Composite Materials

Throughout the sequence of courses Applied Thermodynamics (MFET242), Plastics Manufacturing (MFET348), and Applications of Composite Materials (MFET448), students eventually engage in individual projects related to injection molding simulation within the MFET 448. The attainment of high-quality outcomes in injection molding simulation projects can be attributed to the foundational knowledge gained in Applied Thermodynamics and Fluid Mechanics class, which plays a central role. These achievements are a direct result of students' grasp of practical aspects from the fluid-thermo class and case study presentations. Students have developed their research and presentation skills throughout their experience with case study presentations.

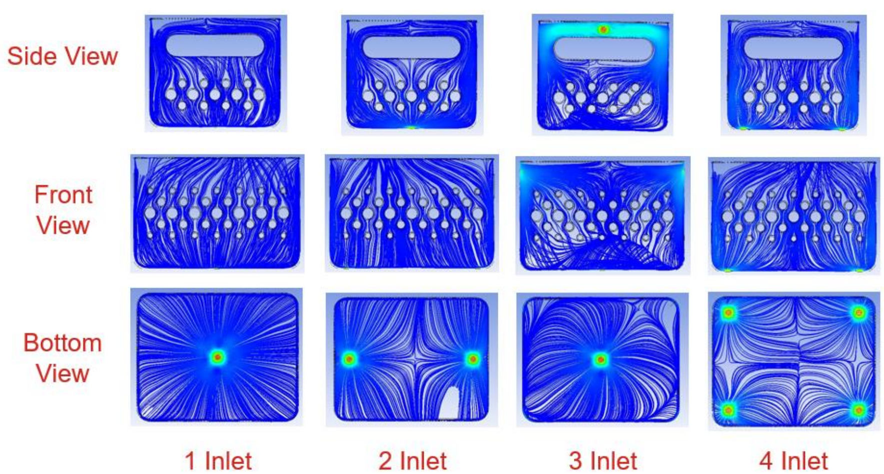


Fig. 9. A student's example of injection molding simulation project: "Plastic Bin Injection Mold."

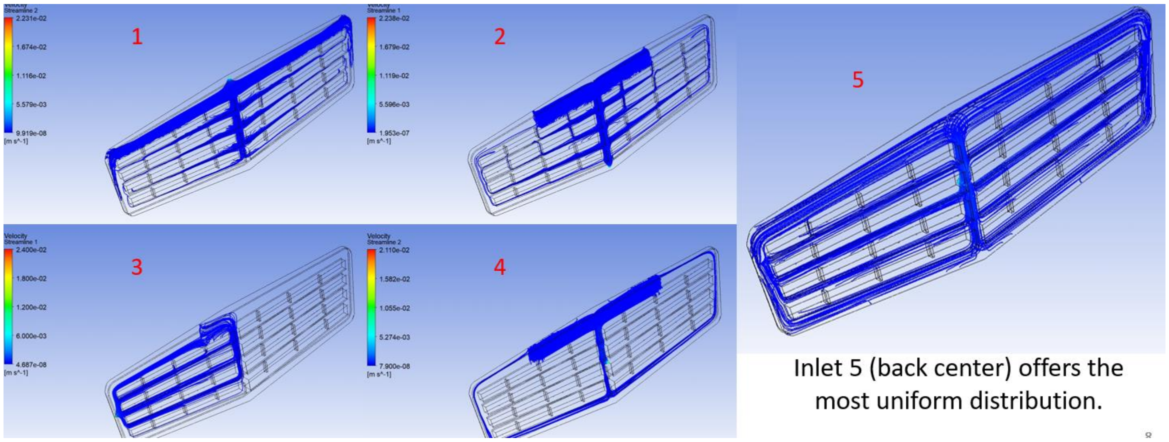


Fig. 10. A student's example of injection molding simulation project: "Automobile Grille."

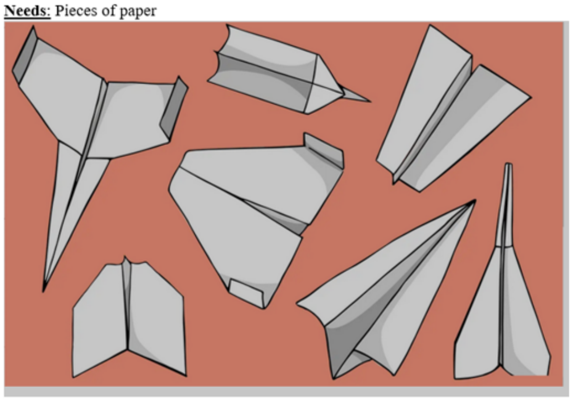
Continuous Improvement of Class from Case Study Presentations

The case study presentations contribute to continuously improve the course each semester. Inspired by several student presentations, a novel in-class activity has been developed to facilitate a deeper understanding of drag force and its relevant equations. Figure 11 illustrates newly designed in-class activity related to drag force introduced in the following semester.

Drag Force: Design Airplane with Reduced Drag Froce

Objective: This lab aims to enhance understanding of drag force and drag coefficient through an airplane design challenge

Needs: Pieces of paper



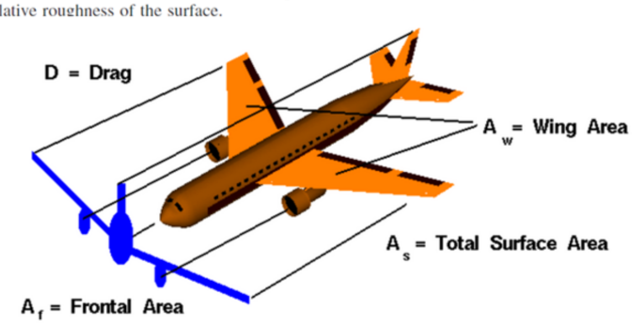
Airplane Design Challenge: Using pieces of paper, design and create at least two different airplanes with the objective of achieving maximum efficiency by reducing drag.

Drag Force Equation and Relevant Information:

The total drag is found from

$$\mathscr{D} = \frac{1}{2}\rho U^2 A C_D \quad (14.21)$$

where ρ is the density of the fluid, U is the upstream velocity, A is the frontal area, and C_D is the drag coefficient. As for the case of the flat plate discussed previously, the drag coefficient is a function of dimensionless parameters such as the Reynolds number and the relative roughness of the surface.



Result & Discussion:

What do you observe? Please provide a brief description of how you designed your airplanes and the resulting outcomes.

Fig. 11. Newly designed lab inspired by case study presentation.

Student Survey and Course Evaluation Results

Course evaluation survey has been conducted twice to support the continuous improvement for Applied Thermodynamics and Fluid Mechanics. The end-of-semester end course evaluations for the course reveal that case study presentations positively impacted the instructor's practical orientation, emphasis on fundamental concepts, provision of deeper learning opportunities, promotion of peer learning, and encouragement of active engagement. Below are some comments from students provided in the semester-end evaluation and a year-after survey regarding case study presentations:

- Gives freedom for students to give out their view about particular topic in class
- Applications of material to real world were good.
- Very applicable material.
- Enjoyed the class very much.
- The applied aspect and real applications were good.
- A strong point was that he always made sure we understood the application of what we were learning and not just going over concepts but how to actually apply them.
- The class covers a wide variety of topics.
- The course gets you to think and helps you to understand what is actually going on from an application point of view. I like that it was not purely based around having to memorize equations or numbers in order to do a problem.
- I enjoyed every lecture. There was always something you could pull away and apply it to the real world.
- After taking this course I can apply everything that I have learned to the real world, as well as being able to analyze a lot more complex situation involving heat and fluid flow.
- The class make all subject material relatable to the real world and places where it happens.
- This course has provided me with a lot of knowledge and insight to things.
- The class taught me a lot of useful information that I can apply to my future endeavors with my degree.
- The class gave a good understanding of how fridge works and how different theories relate to real life.
- The case study was my favorite part and the most critical part of the class for me. As someone who is application focused, it provided me the crucial opportunity I needed to work with the concepts in a broader application while still under the guidance of my instructor.
- Other classes of this matter I find boring and hard to stay interested in. MFET242 breaks that barrier, and projects like this case study presentation help engage students.
- I definitely think that they are worth doing it. Providing 2 weeks for the presentation, with an announcement a week advance, allows students time to determine their topics or give them a list of topics to choose from.
- Very fun to research something in your own interest! It allows you be approachable to the concepts and provides good practice for presentations.

A year-after survey for MFET242 Case Study Presentations was conducted, and the survey questions are displayed in Figure 12. Students who took this class in both spring 2022 and spring 2023 participated in the survey. Even though the survey was not administered right after the case study presentations, it proved somewhat beneficial, as they could objectively assess the presentations after experiencing other classes. The survey results are presented in Figure 13, indicate an overall positive student experience with the case study presentations. Particularly noteworthy are the highest ratings for two questions: Q3, “Did case study presentations stimulate your interest in the subject manner?" with a score of 4.63/5.00 and Q6, "Did case study presentations facilitate active engagement in the class for you" with a score of 4.75/5.00.

Q1	Do you recall your case study presentation topic in MFET242?
Q2	Did you find your case study presentation enjoyable?
Q3	Did case study presentations stimulate your interest in the subject manner?
Q4	Did case study presentation contribute to your comprehensive understanding of fundamental concepts?
Q5	Were you able to learn from peer during the case study presentations?
Q6	Did the case study presentations facilitate active engagement in the class for you?
Q7	Did case study presentations help you focus on practical aspects of the subject?
Q8	Do you believe it is worthwhile to include case study presentations in the class?
Q9	Did the case study presentation help you comprehend practical applications in the real world?
Q10	Did the case study presentations enhance your overall learning experience on the subject?

Fig. 12. A year-after survey questions for MFET242 Case Study Presentations (Scale of 1-5; 1 = very disagree, 5 = very agree)

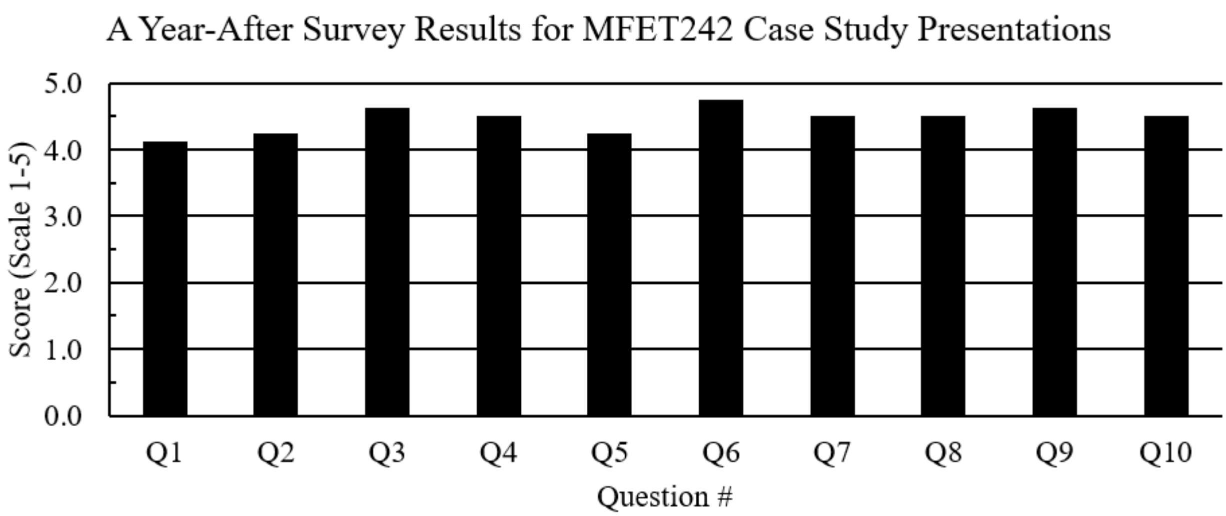


Fig. 13. A year-after survey results for MFET242 Case Study Presentations (n = 9, Scale of 1-5; 1 = very disagree, 5 = very agree).

Incorporating case study presentations into classes requires the instructor's pivotal role. While students learn from peers, the potential for misinformation from the internet necessitates the instructor's corrective guidance. In addition, enhancing the learning experience involves connecting presented topics to relevant concepts and applications covered in class, with a recommended due date set a day earlier for thoughtful preparation.

For a comprehensive data comparison, the course evaluation survey for the case study presentation course (MFET242) is compared with all other classes without case study presentations, as illustrated in Figure 14. All other classes in the data are taught by the same instructor as the case study presentation class. The survey samples include 31 responses for classes with case study presentations and 246 responses for other classes without case study presentations. The average evaluation scores for each question for MFET242 and other classes are converted dimensionless scales for comparison, with the average evaluation scores ratio (%) calculated by $\frac{(Average\ Score\ for\ Classes\ with\ CSP)}{(Average\ Score\ for\ Classes\ without\ CSP)}$. The results indicates minimal differences in responses for most questions, but the ratios for Q1 and Q4 are 103.6% and 104.4%, respectively. This suggests that classes with case study presentations stimulate interest in the subject manner and enhance learning engagement, aligning with the year-after survey results in Figure 13.

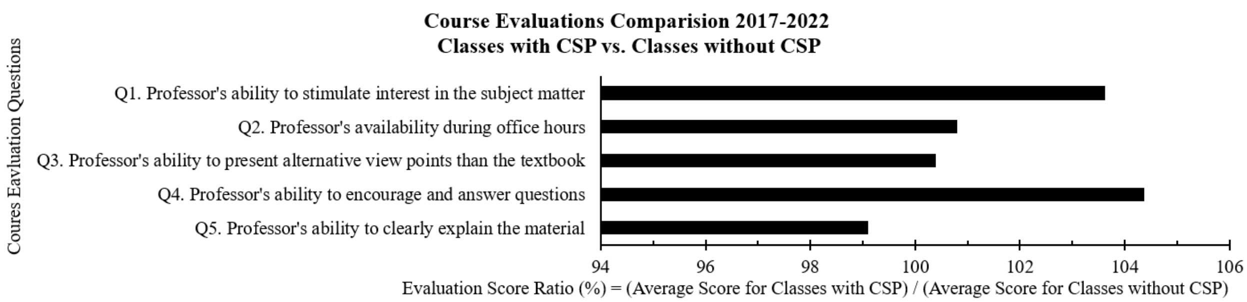


Fig. 14. Course evaluations comparison results: classes with CSP vs. classes without CSP (data from 2017-2022, same instructor).

Conclusion

Integrating fluid-thermo class into manufacturing engineering technology program faces challenging, given the program's broad curriculum and the complexity of the equations in the courses, which may be unfamiliar to students. However, the course remains crucial for the students in the program. Its content not only finds utility in the courses of the program but also proves beneficial for students' future careers. This paper has explained how the utilization of case study presentations can help address these challenges. It encourages instructors to prioritize practical applications and fundamental concepts. It also promotes students deeper learning opportunities, peer learning, active engagement, and continuous improvement of the course. The survey and course evaluation results indicate the utilizing case study presentations stimulate student interest and facilitate active engagement in class.

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Biography

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