2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #38144

Online Labs and DEI in Introduction to Thermodynamics Course

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Abstract

Can online labs improve student learning in comparison to hands-on labs? Do they have space in our curriculum for online and in-person lab offerings? Can some of the lessons learned apply to in-person lab offerings? Can online labs improve the sense of inclusion and belonging?

These questions are addressed in the paper. The paper describes the five labs conducted 100% online in a 3rd-year Introduction to Thermodynamics course in a mid-size comprehensive university's mechanical engineering program. The course comprises 200 minutes of lectures and 125 minutes of labs per week in a 10-week term. The lectures are offered in a flipped format; lectures are pre-recorded, and class periods are used for problem-solving and content clarifications. Lab periods are used for online laboratory exercises and analysis, project check-ins, and periodic reflection. The labs contain pre-lab assignments and in-lab exercises. Pre-labs help students prepare for in-the-lab brainstorming. The in-the-lab work includes watching a video of the lab components, brainstorming the solutions, watching the lab video conducted by the faculty, and doing a group analysis of the results. The learning outcomes intended for the online labs are the same as in-person labs. Occasionally, a few minutes are allocated for reflection during lab periods aimed at increasing inclusion and a sense of belonging for all students.

The one offering of the online labs is compared to two offerings of in-person labs, one preceding and the other after the online offering. Data used to assess the ABET student outcome 6 is compared between the three offerings. A sample of students' qualitative perceptions of the courses is also included. The results suggest that watching the videos instead of conducting the labs themselves allows extra time for in-the-lab analysis of the results and that the quality of lab reports is higher. Three examples are included of how to influence students' sense of belonging without sacrificing too much contact time.

Lessons learned and some online pedagogies were implemented in the subsequent in-person lab offering. That process provided insight into instructional effectiveness in both settings.

Introduction

A thermodynamics course survey by Vigeant et al. 2019 [1] showed that very few programs offer labs in Thermodynamics courses. Our program has integrated experimental design into some thermodynamic laboratories to strengthen students' understanding of fundamental concepts. Our Introduction to Thermodynamics course requires students to learn basic yet complicated concepts, such as determining properties of pure substances, calculating heat and work exchanged during a process, and the first and second laws of thermodynamics before undertaking complex applications such as thermodynamic cycles or combustion systems. These basic concepts are conducive to simple, conceptually oriented laboratory assignments and are an ideal place to have students design an experiment. The learning gains made by switching from traditional lab offerings to experimental design labs were described and reported in [2].

Traditionally, labs are designed for students to collect and analyze data using a prescribed procedure with a preconfigured experimental apparatus. Such labs help to reinforce ideas but don't encourage students to think creatively about processes or how various thermodynamic concepts relate to each other. For example, in a traditional lab, a student might be asked to record the voltage and current consumed by a light bulb and compare that to the heat given off by the bulb. In the experimental design lab students are asked to develop a way to find the efficiency of the bulb. This requires a deeper understanding of the problem. They must determine what type of energy is consumed, how it is measured, how energy is converted in the bulb, the types of energy given off by the bulb, and how that energy can be measured [2]. Paper [2] also showed learning gains when switching from traditional to experimental design labs.

These labs had to be moved into an online format in the fall of 2020. The in-person labs could not be offered as our building was inaccessible due to pandemic-influenced construction delays. That presented a pedagogical challenge: how can we maximize student learning in online labs? An online workshop "How to Engineer Engineering Education" by Michael Prince and Margot Vigeant held on July 14 and 15, 2020 showed that online labs could provide significant learning gains and are even better than traditional labs in some respects. Consequently, the labs were redesigned to enhance student learning and deepen conceptual understanding. This paper offers insights into changed pedagogy and compares the 2020 course offering to two in-person offerings, one in 2019 and the other in 2021.

On the bigger picture, in 2011 the American Society for Mechanical Engineers supported a task force to develop ASME Vision 2030. That paper concludes that successful "mechanical engineers in the industry will, in addition to technical knowledge, need to have increased depth in problem-solving skills, a range of communication skills, and an overall systems perspective." The industry is looking for new skills from graduating mechanical engineers, including effective communication and creativity [3]. However, many mechanical engineering curriculums have seen only minor modifications over decades [4]. Furthermore, effective communication means effective use of current communication methods and tendencies, including awareness of diversity, equity, and inclusion (DEI). How many of those skills are taught and valued in the first three years of the curriculum?

This paper provides an example of how to implement a couple of those concepts into a mid-year engineering fundamentals course without reducing the learning gains or adding more work to already busy students and faculty.

The paper is organized in the following order. First, the courses offered in 2019, 2020, and 2021 are described, followed by a description of pedagogy associated with online lab offerings and key results and takeaways. The role of DEI in the labs and implications for in-person offerings are briefly discussed before conclusions and recommendations. The paper appendices include an example of how to conduct an online lab and an example of student reflections.

Description of the Introduction to Thermodynamics course offerings

The Introduction to Thermodynamics course is a five quarter-credit course, typically taken by third-year mechanical engineering students. The course covers the following topics: thermodynamic properties; equations of state; energy transfer by heat, work, and mass, including an introduction to heat transfer mechanisms; first law of thermodynamics for open and closed systems; second law of thermodynamics; Carnot Cycle; thermodynamic, overall, and isentropic efficiencies; effectiveness of heat exchangers; refrigeration and heat pump cycles, including absorption and cascade refrigeration, and other advanced cycles; air-conditioning processes of humid air; Reheat Rankine cycle including means to improve its efficiency; Otto and Diesel cycles; Brayton with intercooling, reheating, and regeneration; property diagrams, p-v, T-v, T-p, T-s, h-s, p-h, and Psychrometric chart.

This paper examines course offerings in the fall of 2019, 2020, and 2021. The three offerings differed in content delivery methods. Course in 2019 had one-third of the lectures flipped and all labs were in person. Course in 2020 had completely flipped lectures and all instruction, including labs, was online, i.e., remote, and delivered using the Zoom platform. The course in 2021 had completely flipped lectures and all lectures and labs were in-person. Tours were in-person only in 2019 and were online in the 2020 and 2021 offerings. All three offerings were similar in that they focused on active learning during lectures and experimental design in the labs.

The course schedule is shown in Table 1 and is divided into ten weeks; each quarter typically contains ten weeks. Each week has 200 minutes of lectures, with topics shown in the second column. Lab periods take up to 125 minutes per week. Lab schedules for 2019, 2020, and 2021 are shown in Table 1. In 2019, there were 6 in-person labs, offered in weeks 2, 3, 4, 5, 7, and 8, and the lab session in week 10 was reserved for a two-hour tour of HVAC systems used to air-condition medical research laboratories at Fred Hutchinson Cancer Research Center, as shown in 3rd column in Table 1. Labs were not held in week 1 because it was too early in the content coverage, and at least one lab period was assigned for makeup labs and office hours. Labs 1-3 and the learning benefits of experimental design over traditional lab offerings were described in detail in the paper [2]. Labs 1-3 were chosen for experimental design because they do not require expensive equipment and address fundamental concepts. The goal, as described in [2], is to have students do experimental design in small groups so that everyone benefits from participating in the design and synthesis of the experiment. Labs which rely on expensive and complicated equipment, such as refrigeration or air-conditioning labs are not conducive to experimental design in small groups. The refrigeration lab, for example, utilizes a demonstration system built by P. A. Hilton, an older version of the currently available unit [5]. The goal of that lab is to demonstrate how the components of a refrigeration cycle work and interact, as opposed to discovering some fundamental concepts in thermodynamics. The discovery of fundamental concepts is more conducive to experimental design in this setting.

In the fall 2020 course offering, all instruction, including labs, was online. The remodeling of the building that hosts our lab equipment began earlier in the year. Construction delays made laboratory spaces inaccessible, so we had to adjust to fully remote teaching. The course was completely flipped for the 2020 offering, and pedagogical concepts associated with active learning in the remote-teaching environment were adopted from [6]. The online labs presented an additional challenge, but active learning pedagogy applied there as well. In 2020, the number of labs was reduced to 5, offered in weeks 2, 3, 5, 7, and 8, as shown in the 4th column in Table 1. A project was added in weeks 9 and 10 to make up for the reduced number of labs. The refrigeration and air-conditioning labs could not be conducted online since the equipment was stored in an inaccessible building. A tour was replaced by a virtual tour offered during lecture time so that all students could attend. Extra lab time was repurposed for problem-solving, i.e., extra practice before the exams, as well as extra office hours for lab and exam questions. That extra time seemed appropriate to focus on student well-being during tough remote-learning times.

In the fall 2021 course offering, instruction was back in person, but some pandemic restrictions remained; particularly, the tours were held virtually. As noted in Table 1, labs were held in weeks 2, 3, 5, 6, 8, 9, and 10. Lab period in week 4 was held as consultation for Lab 2, to offer time for analysis. This is because brainstorming experimental design and conducting lab in person in week 3 filled up the lab period, not leaving enough time to do the analysis. The refrigeration and air-conditioning labs were offered again, and the experimental design lab for the in-home refrigerator was offered again, following the success of the assignment in 2020 offering. Labs 4 and 7 are discussed later in this paper. There was no time for the project in the 2021 offering.

Table 1. Overview of the Introduction to Thermodynamics course schedule per each week of a quarter class is offered

Week	In-class topics	Labs in 2019 *In-person*	Labs in 2020 *Online*	Labs in 2021 *In-person*
1	thermodynamic properties; 0th Law; energy transfer by heat, work and mass; boundary work			

2	1^{st} Law for closed systems; thermodynamic efficiency; heat transfer mechanisms	LAB 1 *Experimental Design Electro-mechanical system*	LAB 1 *Experimental Design Electro-mechanical system*	LAB 1 *Experimental Design Electro-mechanical system*
3	Property diagrams (T-v, p-v, T-p) and phase-change processes of pure substances; equations of state	LAB 2 *Experimental Design Energy Conversion*	LAB 2 *Experimental Design Energy Conversion*	LAB 2 *Experimental Design Energy Conversion*
4	1^{st} Law for open systems undergoing steady or unsteady-flow processes	LAB 3 *Experimental Design Absolute zero*	Exam prep	*Energy Conversion* Consultation period
5	Carnot Cycle; Irreversibilities; Entropy generation; 2^{nd} Law; 3^{rd} Law; T-s & h-s diagrams; Isentropic Efficiency;	LAB 4 *Ideal Gas Law*	LAB 3 *Experimental Design Absolute zero*	LAB 3 *Experimental Design Absolute zero*
6	Ideal refrigeration and heat pump cycles: simple, cascade, multistage, multipurpose, and absorption; p-h diagrams	LAB 5 *Tour*	Exam prep	LAB 4 *Engineering Analysis Autoignition*
7	Air-conditioning processes of humid air: heating, cooling; humidifying, de-humidifying, mixing; Psychrometric Chart	LAB 6 *Refrigeration*	LAB 4 *Engineering Analysis Autoignition*	Lab make-up period
8	Gas power cycles; Otto, Diesel, Dual cycles;	LAB 7 *Air-conditioning*	LAB 5 *Experimental Design In-home refrigerator*	LAB 5 *Refrigeration*
9	Brayton Cycle with intercooling, reheating, and regeneration; Tour preparation	Lab make-up period	*Project Introduction*	LAB 6 *Air-conditioning*

10	Rankine Cycle and means to increase its efficiency; Rankine with reheat; Combined gas-vapor cycles	LAB 8 *Tour*	*Project discussion*	LAB 7 *Experimental Design* *In-home refrigerator*

Description of the online labs

The learning outcomes associated with the online labs are the same as in-person labs:
1. Design an experiment to gain necessary information about a system
2. Analyze and interpret experimental data
3. Draw conclusions based on data analysis and engineering judgment

Each of the labs is preceded by lectures and homework that cover related theoretical concepts. Weekly lab assignments are listed in Table 2 for the virtual lab offering in fall 2020. The table indicates whether the students are asked to complete a pre-lab assignment before the lab and whether students write a formal lab report or create a video. Of the five labs, four include experimental design. Those are labs 1, 2, 3, and 5. Those labs were described in detail in [2]. Lab 4 is new and is included in Appendix 1; it includes an in-lab assignment.

Table 2. Overview of the online labs conducted in the Introduction to Thermodynamics course

Name	Pre-Lab	Report (R) or Video (V)	Description
LAB 1 *Electro-mechanical system*	x	R	Design an experiment during a lab session to evaluate the performance of a thermoelectric device [2]
LAB 2 *Energy Conversion*	x	R	Design an experiment during a lab session to determine the efficiency of an electric light bulb [2]
LAB 3 *Absolute zero*	x	R	Design an experiment during a lab session to predict the value of absolute zero [2]
LAB 4 *Autoignition*		V	Follow prompts in the in-lab assignment (see Appendix 1)
LAB 5 *In-home refrigerator*	x	R	Design an experiment in a lab report

When offered online, the pedagogical approach to experimental design had to be altered. The implementation for labs 1-3 was in the following order:

1. Pre-lab is assigned 5 days before the lab and is due at 8 am on the day of the lab. Each Pre-lab aims to incentivize students to review theoretical concepts relevant to the lab content. This was the same in person as in online offerings.
2. At the beginning of each period, students are asked how they are doing. This was the same in person as in online offerings. But it had special meaning in the online offering. There, students were sometimes asked to express themselves anonymously on a Zoom whiteboard, an experience that many enthusiastically pursued. An example of the "Exhalations" whiteboard, given in 6^{th} week of the term, is in Appendix 2.
3. Then, students are asked to watch a short, pre-recorded video that describes the equipment. The video is also posted onto the learning management system if they want to watch it again. Each piece of equipment is described in detail with a focus on giving students an understanding of the equipment's sizes, materials, functions, etc. They are invited to ask questions during and after the video. This is different from in-person labs, where students have hands-on access to equipment and can ask questions while physically inspecting the equipment.
4. Next, students are divided into teams and asked to join their team's Zoom room, where they are given 10 minutes to brainstorm how they would design an experiment using the equipment given. Students gave early feedback that brainstorming should be at least 10 minutes long. The faculty joins each room and helps students in their thinking process. This is different during in-person labs, where faculty physically moves from one lab bench to another to talk to the teams.
5. All gather in the main room and ask questions of the faculty; the faculty shares some ideas and explains concepts to everyone. This resembles what happens in person.
6. Students go back into their Zoom rooms and brainstorm for 15 minutes, with faculty visiting each room. Extra time is given if requested or needed. The faculty assesses the state of task attainment by each student by asking questions and encouraging each team member to participate in answering.
7. All gather in the main room, share and discuss ideas on designing that experiment, and ask questions. Afterward, all watch a 5-minute video of the faculty conducting the experiment. During in-person labs, students spend up to an hour assembling and conducting the experiment. Hence, little time is left to analyze and discuss the results.
8. Students go back into their Zoom rooms and analyze what they saw for about 15 minutes. The faculty drops into the Zoom rooms frequently. More time is allotted if needed.
9. All gather in the same room to share their analysis and discuss. Faculty explains unclear concepts.

Steps 8 and 9 typically do not occur in the in-person labs because there is no time. Assembling and conducting experiments typically take all the remaining time in the lab period. Hence, analysis of the experimental results is a learning gain unique to online labs. That is, although students in online labs lack the opportunity to experience equipment and experimental phenomena physically, they gain insight into the analysis of what is happening. That, in turn, helps them write reports that show evidence of deeper conceptual understanding.

Lab 5 is another example of deeper learning in online labs. This lab is a thought experiment. In the 2019 in-person offering, that experiment was not discussed during lab time. Instead, students were encouraged to ask questions during office hours. Since student performance was unsatisfactory, an entire lab period was dedicated to it in 2020. A significant improvement was noted in the 2020 offering compared to the 2019 and results are shown in Table 3. Table 3 shows the average scores assigned to lab reports in two categories:

6a - Design an experiment to gain necessary information about a system.
6c - Analyze and interpret experimental data.

These two categories are performance indicators (PE) used in our BSME program's assessment and feedback loop process associated with ABET Student Outcome 6 [7]. Table 3 shows the average scores assigned to student work used to assess PE 6a and 6c in course offerings in 2019, 2020, and 2021. PE 6c was assessed in Lab 2 reports and requirements were unchanged in all three course offerings. PE 6a was assessed on the same assignment, Experimental Design of In-home Refrigerator, offered as Lab 6 in 2019, Lab 5 in 2020, and Lab 7 in 2021. Requirements were unchanged in all three course offerings. T-test was performed using MS Excel for two-tailed samples with unequal variance for two data sets: 2019/2020, and 2020/2021. The p-values are less than 0.05, showing significant differences in the data sets. Table 3 shows that scores in 2020 were significantly higher than scores in the other two offerings.

Table 3. Average scores for assessing ABET performance indicators 6a and 6c in course offerings 2019, 2020, and 2021.

Year course offered	2019	2020	2021	2019	2020	2021
Performance Indicator	6a	6a	6a	6c	6c	6c
Average score [%]	73.6±12.0	87.0±9.5	74.8±28.5	74.3±27.3	90.1±7.3	82.2±22.9
p-value 2019 to 2020	3e-7			3e-4		
p-value 2020 to 2021		0.01			0.01	

Lab 4 assignment deliverable was different from the rest because it was intended to develop modern communication skills other than report writing. It required students to record a one-minute video that physically describes what's happened in a way that is engaging to the audience. The assignment videos were graded on the quality of their technical content, production quality, originality, and creativity. The motivation for the assignment came from the realization that videos are nowadays widely used to communicate technical content. The idea of videos as a form of lab reports came from the ASME webinar by Dr. Yeow Siow from the University of Illinois – Chicago [8]. Dr. Siow graciously shared his assignment [9] which was subsequently modified for the current application. The script for conducting that 75-minute lab and the accompanying assignment are included in Appendix 1.

Student perception of the course offerings

In 2019, students identified labs and tours as *the most memorable hands-on experience*. One student wrote: *The laboratory section was helpful to see how the theories applied in real life*.

Interestingly, in 2020, students still praised the labs. For example, one student wrote: *The labs were interesting and added to learning*. Another enjoyed a *variety of learning (labs, hw, exams).*

A suggestion for improvement in 2020 was: *Having breakout rooms go a little longer than 5 minutes was a good change. I think we were always confused at the beginning of our labs, so I think if we worked at first to make a list of givens and assumptions it can help steer our thinking into what we should do (for labs where we designed it).*

One student wrote the following comment, which summarized the sentiments of many in the 2020 offering:
Lots of resources! I enjoyed the flipped classroom, and the diverse tactics of teaching styles. Recorded lectures, in class examples, recorded examples, etc. Plenty of office hour time

In 2021, lab improvement suggestions were: *Potentially making it more clear what the lab entails in the prelab assignment; The lab assignments were difficult because they were vague. A little more guidance would be helpful; I think in laboratory session needs more encouragement to be included in the group.*

This last comment suggests the importance of paying attention to the inclusion of all team members.

Role of DEI in labs

Over the past five years, our department underwent annual reviews by an external evaluator Inverness Research, sponsored by a National Science Foundation grant [10]. Their 2019 review revealed instances where students did not feel included. These situations involved faculty, staff, and students within both curricular and extra-curricular settings. Since becoming aware of the situation, the department has spent considerable time addressing inclusivity. All faculty attended microaggression and inclusion training [11]. Thermodynamics faculty piloted a syllabus that includes a policy on microaggressions and harassment, termed the SU ME Department Diversity, Equity, and Inclusion (DEI) syllabus statement. The Department consequently adopted the statement, as has the college. The DEI syllabus statement is verbatim included below.

SU ME Department Diversity, Equity, and Inclusion
Seattle University and the Department of Mechanical Engineering are committed to creating and sustaining an inclusive culture that values diversity and works for equity in opportunity and outcomes. Diversity is a core value we espouse as part of our mission. We respect our students'

identities and we strive to create a learning environment where every student feels welcomed and valued.
We ask for your help in fostering a welcoming and open environment, treating others with respect, and collaborating toward equity. Please refer to the Student Code of Conduct and to the Office for Diversity and Inclusion for more information and guidance. If you personally experience bias, harassment or discrimination, or witness any of these, you are encouraged to reach out to your instructor, your advisor, the ME Department office, the College Advising Center, Diversity, Equity, and Inclusion Student Ambassadors (Instagram: su_stemdei), or any of the resources listed on the SU Diversity and Inclusion resources page including the Office of Institutional Equity.

DEI syllabus statement is read to students on the first day of class as well as another time throughout the term. With that, the faculty aims to convey the importance of DEI. External evaluator Inverness Research reported that student focus groups identified the DEI syllabus statement as an important sign that the department is working on strengthening its inclusive culture.

Honing the concept further, the faculty piloted Inclusivity Meter in 2020, an online poll administered through the Zoom platform, to generate data on the following:

Did I feel included in lab team meetings last week?
- *Totally*
- *Pretty good*
- *Yes and no*
- *Somewhat*
- *Not at all*

This poll was administered in the third week of the term. Results were shared in aggregate and time was allowed for group discussion and for students to reflect on their meaning. The intent was to remind students of the importance of the inclusion of all team members.

Inclusivity Meter and "Exhalations" whiteboards were not utilized in the 2021 session.

Implications for in-person labs

Replacing one lab report with a short video assignment that emphasizes creativity reduces the grading workload and provides students with an opportunity to learn to describe technical content in a modern communication style.

Significant improvement in the quality of lab reports in 2020 over 2019 offering suggests the importance of dedicating considerable time to data analysis. In the case of these fundamental labs, a minimum of 45 minutes should be used for data analysis, partially in teams individually consulting with faculty, and partially in discussion with the entire lab section. In 2021, attendance during the analysis period was not mandatory, and the quality of reports declined in comparison to 2020. Deeper conceptual understanding may be improved if attendance at analysis periods is required.

The quality of assignments may be linked to a feeling of inclusion and belonging. One student in 2021 asked for *more encouragement to be included in the group.* Students benefit from reflection. The Inclusivity Meter and "Exhalations" were appreciated by the students in 2020 and should be used in future offerings.

Finally, the quality of assignments may also be linked to the effect of flipped classroom instruction on student learning, the quality and motivation of students, and grading inconsistencies, none of which were assessed in this work.

Conclusions and Recommendations

This paper describes pedagogy for offering online laboratory exercises. It provides an example of an online lab script. It also discusses the importance of DEI concepts when conducting labs. During online labs, the students did not conduct experiments on their own. That allowed extra time during a lab period to analyze the results that faculty obtained when they conducted labs. The lab reports were significantly better in the online lab offering. This implies that extra time should be included for analysis during in-person labs. Replacing a lab report with a video assignment prepares students to communicate using modern methods. Emphasizing the importance of DEI during lectures and labs is important to many students and may influence the quality of their work.

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Appendix 1 An online lab script

Lab 4 In-lab and Post-lab Assignments

Lab 4 In-lab Assignment

This is a 75-minute lab

10 minutes – How are you?
15 minutes – Watch video of the equipment and how compression ignites a piece of tissue in the cylinder
15 minutes - In lab class, Dr. Shuman e-mails a questionnaire and asks everyone to fill it out and submit a questionnaire:

- During compression, what goes up? (circle the right answer)
  - Pressure?
  - Temperature?
  - Both?
  - Neither?
- What is the thermodynamic system here?
- Does the speed of the plunger make a difference? In other words, is the tissue more likely to ignite if we compress it slowly or fast? Explain your answer.
- Can you write an equation that describes what happens in this experiment to the air in the cylinder?
- Draw a p-v diagram and sketch how you think the process(es) look on it.
- Draw a T-s diagram and sketch how you think the process(es) look on it.

7 minutes - In-lab discussion in Breakout sessions.

- Suggest to students that what works best is if they reveal what they did not know how to answer.

20 minutes - Group discussion led by Dr. Shuman

- What did you not know how to answer?
- Go back and review your answers to the questionnaire

5 minutes – Explain the post-lab assignment and adjourn.

Lab 4 post-lab assignment

Watch PASCO Compression Ignition Demo: https://www.youtube.com/watch?v=lGQeTSdusy8
And this Compression Ignition Demo: https://www.youtube.com/watch?v=4qe1Ueifekg
Lab report: Record a short video (up to 1 minute long) that answers the above questions and is fun and professional at the same time. Make a video that others want to watch but that has technical content. Here are the rules:

Rules:

- Video must be less than one minute long
- Must show your face – at least intermittently
- Must voice narrate your explanation
- Must hear your voice clearly
- Individual work

Tips:

- Make it fun yet educational
- Shoot plenty of raw footage
- Edit video by using a free software
- Speak close to the mic
- Watch it before submitting – proof it!

Grading rubric:

	WOW FACTORS				Max Possible
	3	2	1	0	
Creativity and Originality	Mind Blown	Substantial	Some evidence	Missing	15
Technical Soundness	Explanations, sketches, equations, and plots are accurate	Generally correct with some details missing	Incorrect physics and/or missing most details	Missing	15
Production Quality	Stunning visuals, clear audio, and smooth editing	Generally good quality with some issues	Can't make out some visuals and/or barely audible, and/or incongruent editing	Missing	15
					45

Appendix 2

An example of Zoom whiteboard "Exhalations" in the 6th week of the 2020 term.