Effectiveness of flipped vs traditional course structures in upper division oceanography courses

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Abstract

In the past decades the introduction of online and remote learning has created the need for new ways to teach content that focus on the active learning component of teaching, one of these methods is the flipped course structure. My study evaluated the effectiveness of flipped and traditional course structures in teaching upper division oceanography online. Using two upper division oceanography courses, Marine Geology and Geochemistry (OCEAN 310, traditional structure) and Fluid Dynamics and Waves (OCEAN 285, flipped structure), I assessed the effectiveness of these courses using three different metrics: student grades, student responses to a survey about the effectiveness of course elements, and IASystem course evaluations. I found that students in OCEAN 285, which was a flipped structure for the first time in Autumn of 2020, had higher grades than previous years while students in OCEAN 310 had similar grades as compared to previous years. The course effectiveness survey showed that problem sets in the flipped course (OCEAN 285) were the most effective course element across both courses. Finally, while overall course evaluation scores were lower in 2020 than in previous years for both courses, OCEAN 285 maintained higher scores than OCEAN 310. There are however, many uncontrolled variables in this study, and more research in needed to understand the relationship between course structure and effectiveness including how changes to assignments influenced grades in both courses.

Plain language summary

This study looked at how the structure of courses and how they are taught influences how effective the course was overall. I studied how flipped structure courses, courses where lectures are replaced with activities during in class time, compare to traditional structure courses. In traditional structure courses lectures occur during class time. I specifically focused on courses that are required as part of the oceanography major. I used three metrics to compare these courses: student grades, student

responses to a survey I created about how effective individual pieces of the course were, and responses to the university course evaluation that is sent out for all courses. Using these metrics I found that the flipped course structure preformed better under each broad metric. Student grades in OCEAN 285 improved as compared to previous years, they ranked the main course elements as being more effective than OCEAN 310 students, and while course evaluation scores did go down in 2020 as compared to previous years they went down less in OCEAN 285. However, there are other influences in this study besides just the course structures changing, and this study only represents one instance of these courses and other factors may have influenced students perception these courses in 2020. Overall, more research needs to be done to determine how course structure can influence the effectiveness of upper division oceanography courses.

Introduction

Course structures have been studied in higher education both before and during the COVID-19 pandemic. Pre COVID-19 studies suggest that courses that implement flipped course structures can have benefits over courses taught with traditional course structure (Unal and Unal, 2015). There is not a rigid definition of a flipped course structure, but it usually describes courses that have taken material that is traditionally presented during scheduled course time (e.g. lectures) and moved it to be presented outside of scheduled course time via an online method. Scheduled course time is then used for course elements that are traditionally done outside of scheduled course time (e.g. problem sets) (O'Flaherty and Phillips, 2015). Traditional course structure describes a course where material that is traditionally presented during scheduled course time is presented during course time (e.g. lectures) and course elements like problem sets are completed outside of the scheduled course time (Table 1).

Table 1. General examples of when different course elements occur in flipped and traditional course structures

Course Structure	Occurs during scheduled course time	Occurs outside of scheduled course time
Flipped	• Problem sets • Other activities	• Lecture • Readings • Quizzes
Traditional	• Lectures • Quizzes	• Problem sets • Reading

In a review published in 2015 about flipped course structures, O'Flaherty and Phillips came to the conclusion that the majority of courses found positive educational outcomes when a flipped course structure was implemented (O'Flaherty and Phillips, 2015). Another study by Unal and Unal (2015) concluded as well that in the majority of cases they studied students had higher learning outcomes, meaning students had a better mastery of the subject, in a flipped course structure as compared to a traditional structure. Their study focused on K-12 schools and looked at English, math, social studies, and science courses. This shows that across subjects and grade levels a flipped course structure tends to improve learning outcomes of courses. Two main drivers that could account for this success are that students can set their own pace during pre-recorded lectures and that the active component of learning (problem sets) occur during time when they are supervised and can ask for help (Lo et al., 2018)

During the COVID-19 pandemic, when the majority of courses transitioned to remote learning, some instructors chose to change the structure of their course to a flipped course structure when it was previously a traditional course structure. From this time period of "emergency transitions" there have been few studies published that track the success of the transition. Most of these studies focus on a specific course and how successful different elements of these transitions were. One of these studies, Krull and Gillis (2020), focused specifically on how different course elements contributed to student

success in two different sections of an introductory level sociology course, one section taught by Krull and the other by Gillis. The most effective course elements that they used were small group video chats and live zoom discussions, over 70% of their students found these elements to be “very effective”. However, there were some large variations across course sections in what was identified as effective. In Krull’s section 61.5% of students found forums to be “very effective” but in Gillis’s section only 17.5% of students identified the forums to be “very effective”. The authors give several possibilities for the reasoning behind this, one of which being that Krull had previous experience teaching in an online environment as was able to format the forums differently than Gillis based on previous knowledge (Krull and Gillis, 2020). This highlights that even when the course being taught is comprised of the same content that individual professors can contribute to how effective a particular element is based on numerous factors.

Student attitude toward flipped structure courses have also been studied. Students can struggle with a flipped course structure at first, and students with higher cumulative GPAs tend to adapt faster than others (Holte and Garrow, 2015). Another study found that students took approximately 4 weeks to adjust to a flipped course structure in an upper-division engineering course (Mason et al, 2013). In this particular study, students also identified that they thought it was appropriate to use a flipped course structure in upper division courses, but none would suggest it for a first year course due to the amount of self-discipline it takes to complete tasks outside of scheduled course time (Mason et al, 2013). Another concern that students reported with flipped learning is that students do not have the ability to ask questions during the pre-recorded lectures, however this did not impact their overall performance in the course (Holte and Garrow, 2015). Finally, a review identified the most common problem that occurs in flipped courses is that students may not come to course prepared, and will learn less as a result, this result was present in 13% of the studies they reviewed (Akçayırb and Akçayırb, 2018).

There have been no studies that specifically study the effects of a flipped course structure in any oceanography course. However, as previously stated, flipped course structures tend to improve learning outcomes across many different subjects, including the related fields of introductory chemistry, biology, and physics (Seery, 2015; Awidi and Paynter, 2019; Asiksoy and Ozdamli, 2016). In one case, undergraduate introductory biology was taught in a flipped structure before the COVID-19 pandemic and was found be effective, however a major driver identified in student success was student motivation (Awidi and Paynter, 2019). Gillis and Krull (2020) identified in their study that student motivation was a barrier that students were facing in COVID-19 times. What worked in pre-COVID times may no longer be the most effective due to barriers that students are currently facing. Studying two oceanography courses with different course structures will help to build understanding of how course structure contributes to the effectiveness and student experience in oceanography courses. This study can help shape how oceanography courses should be structured moving forward during the current period of remote learning and it will be possible to apply the knowledge gained from this study to in-person courses as well.

My research focuses on answering the following questions: How does moving a course online affect the effectiveness of the course, as well as the overall experience of students in the course? And how does course structure impact the effectiveness and overall experience of students in a course? The hypothesis that I am testing is that both courses will have a decrease in course effectiveness and that they will be less enjoyable and accessible to students resulting in a lesser student experience as compared to when the courses were taught in person. I also expect that OCEAN 285/286/240 as the flipped structured course will be more effective, enjoyable, and accessible to students than OCEAN 310 as the traditionally structured course.

I evaluated two courses within the School of Oceanography that are both requirements for the oceanography major, OCEAN 310 and OCEAN 285/286/240. OCEAN 285/286/240 was a flipped structure and OCEAN 310 was a traditional structure course, both were taught via remote learning. Autumn 2020 (AU20) was the first time that both courses are being taught in remote learning format and the first time that OCEAN 285/286/240 has been taught in a flipped structure.

Ocean 285

OCEAN 285/286/240 transitioned from a traditional course structure to a flipped course structure in Autumn Quarter 2020 (AU20). Lectures went from occurring during scheduled course time to outside and were significantly shortened. Problem sets, which students traditionally worked on outside of course time now take up the bulk of the scheduled course time. Students were placed into 8 groups of 6 students with supervision and help from a teaching assistant or instructor, each of whom looks after two groups. Pre-course preparation occurred for every day of the course and consisted of watching up to three short (2-10 minute) videos and reading excerpts from an online textbook. Before AU20 lectures were three synchronous 50-minute lectures a week, in a traditional course format. Both before and during AU20 students completed a quiz on the basic concepts present in this material- one quiz per day the course meets, all due at the end of the week. In AU20 the midterm was optional and students could take it for participation credit but did not otherwise contribute to their overall grade, this was due to political events that happened during the scheduled week of the midterm, and was not palnned. The final exam was synchronously taken during course time and counted for ~20% of the final course grade. In previous years, both of these exams would have been taken synchronously during course time and both counted toward the final grade (Table 2). Lab in years before AU20 was an optional 2-credit course under the code OCEAN 286, this year lab consists of a 1-credit mandatory course under the code OCEAN 240.

Table 2. Breakdown of course elements present in OCEAN 285/286/240, AU19 is representative of the last 5 years of instruction

	Ocean 285 AU19	**Ocean 285 AU20**
Lecture	During course time	Outside of course time
Reading	Outside of course time	Outside of course time
Problem sets	Outside of course time	During course time
Quizzes	Outside of course time	Outside of course time
Midterms	During course time	Outside of course time
Lab	During course time***	During course time*
Office hours	Outside of course time	Outside of course time

***OCEAN 285/286 lab from AU19 was a 2-credit optional course

*OCEAN 285/240 lab from AU20 was a 1-credit mandatory course

OCEAN 310

OCEAN 310 remained a traditionally structured course in AU20, as it has been in previous years. Live lectures were 50 minutes long and occur Monday, Tuesday, and Wednesday during the scheduled course period. This was the same as in previous years except that they were presented over Zoom instead of in person. There was one lab a week that students start during scheduled lab time and if they do not finish it is completed outside of scheduled course time and turned in the next week. Students were quizzed on major course content once a week during course time. There was supplementary reading assigned during the week that can be completed outside of course time, the same as previous years. Pre transition to remote learning midterms were taken during course time and were closed book. This year, exams were given as 4-day open note take home exams. Problem sets are not a course element present this course (Table 3).

Table 3. Break down of when course elements are present in OCEAN 310, AU19 is representative of the last 5 years of instruction

	Ocean 310 AU19	**Ocean 310 AU20**
Lecture	During course time	During course time
Reading	Outside of course time	Outside of course time
Problem Sets	N/A	N/A
Quizzes	During course time	During course time
Midterms	During course time	Outside of course time
Lab	During course time**	During course time**
Office Hours	Outside of course time	Outside of course time

**OCEAN 310 labs often take longer to complete than the scheduled course time and are finished outside of scheduled course time

Methods

Grade distributions

Each set of grades was processed by code that counted the occurrence of each grade point in the data in the two time periods specified for each course. All satisfactory/ not satisfactory grades were removed. The GPA grades were then converted into letter grades using the UW standard grading system(Appendix 1). These occurrences were then divided by the total number of grades in each time period and turned into percentages and graphed as a distribution.

Course Evaluations

Course evaluations were accessed from 2016-2020 for each course. 2020 evaluation rating are taken directly from the summery of rating that was provided to professors. 2016-2019 are an average. Course evaluations were conducted by the University of Washington IASystem.

Survey

The survey was written using a verified survey from the University of British Columbia and a survey developed by Krull and Gillis for their research. The survey was in a Google form, and was provided to the students in each course. The survey asked students to indicate how effective, enjoyable, and accessible each course element in their course was. The options for each question included extremely, very, somewhat, a little, and not at all for each question and course element. The survey responses were anonymous. A full list of survey questions can be found in Appendix 2.

They survey responses were trichotomized, meaning that the extremely and very responses were added and made into a positive category, the somewhats were made into a neutral category, and the little and not at all responses were added to create a negative category. The three categories were then represented as a percent of total responses for each course element and question.

Human Subjects Division and data sets

I applied through the human subject division at UW to obtain permission for my research. I was given the determination that my study did not qualify as research, and that I could go ahead in obtaining the data I needed without further permissions (Appendix 3). I obtained the grade and demographic information for all students that have taken OCEAN 285 from 2016-2020 and OCEAN 310 from 2017-2020. This information was de-identified before I received it. From there I split the data into 2020, and previous years for each course.

Results

Grade distributions

OCEAN 285 students had higher average grades in 2020 than previous years (Table 4). OCEAN 310 students had lower average than previous years (Table 4). Overall, grade distribution in OCEAN 285

was different than previous years, going to a distribution skewed to A's, from 2016-2019 14% of students received A's and in 2020 45% of students received A's (Figure 1). Grade distribution in OCEAN 310 was very similar to previous years, both representing a slight double bell curve (Figure 1). From 2017-2019 13% of OCEAN 310 students received A's, and in 2020 8% of students received A's.

Table 4. Figure 1. Final grade averages in Fluid Mechanics and Waves (OCEAN 285, $n_{2016-2019}$=128, n_{2020}=46), a course with a flipped course structure starting in 2020, and B) Marine Geology and Geochemistry (OCEAN 310, $n_{2017-2019}$ =95, n_{2020}=34), a course with a traditional course structure through all time periods.

	Ocean 285		**Ocean 310**	
	2016-2019	2020	2017-2019	2020
Average Grade	3.2	3.7	3.1	3.0

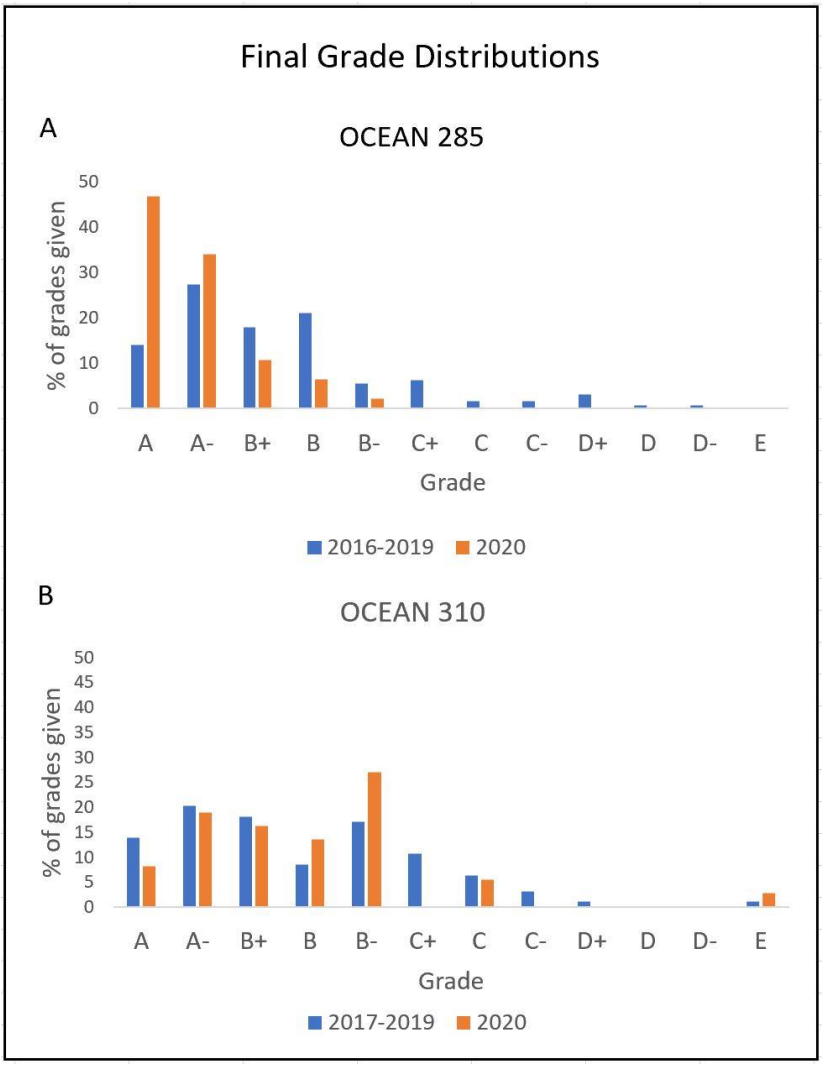

Figure 1. Final grade distributions in A) Fluid Mechanics and Waves (OCEAN 285, $n_{2016-2019}$=128, n_{2020}=46), a course with a flipped course structure starting in 2020, and B) Marine Geology and Geochemistry (OCEAN 310, $n_{2017-2019}$ =95, n_{2020}=34), a course with a traditional course structure through all time periods. In panel A blue represents 2016-2020 and orange represents 2020. In panel B blue represents 2017-2020 and orange represents 2020

Survey

A higher percentage of OCEAN 285 students ranked course elements as extremely or very effective than OCEAN 310 students (Figure 2). OCEAN 285 problem sets had the highest percentage of students who identified the course element as extremely or very effective at 93% of responses. For lectures, OCEAN 285 had 45% of students identify them as extremely or very effective while OCEAN 310 had 53% of students identify them as extremely or very effective. Exams also had a higher percentage of people identify them as extremely or highly effective in OCEAN 310 than OCEAN 285.

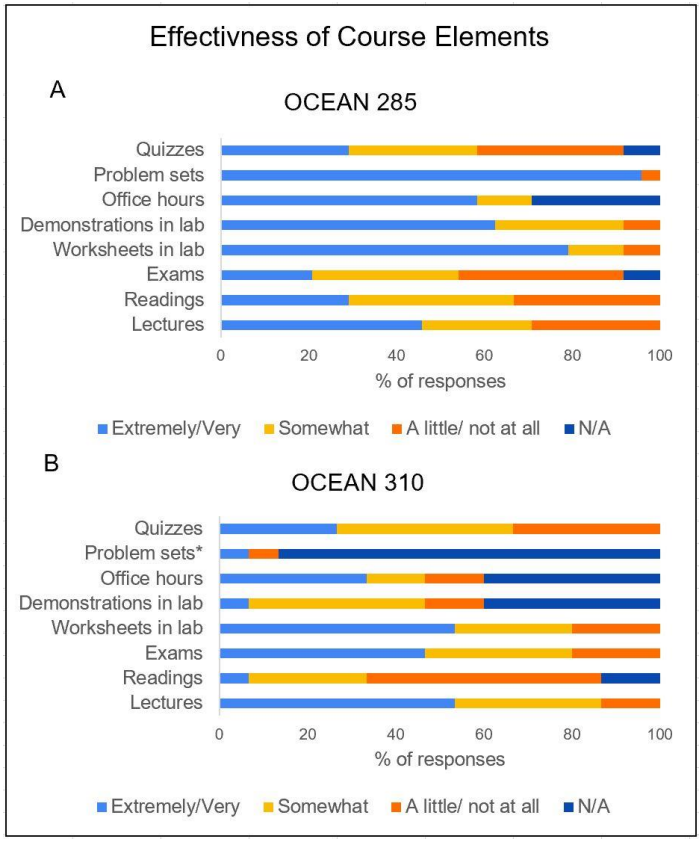

Figure 2. Survey responses of effectiveness of course elements in A) Fluid Mechanics and Waves (OCEAN 285, n=25) and B) Marine Geology and Geochemistry (OCEAN 310, n=14) in Autumn of 2020. In panel A and B light blue represents extremely and very effective, yellow represents somewhat effective, orange represents a little/not at all effective, dark blue indicates that students identified the course element as Not applicable

**Course element not present in course*

A higher percentage of OCEAN 285 students ranked course elements as extremely or very enjoyable than OCEAN 310 students (Figure 3). Students ranked the accessibility of course elements similarly across both courses (Figure 4).

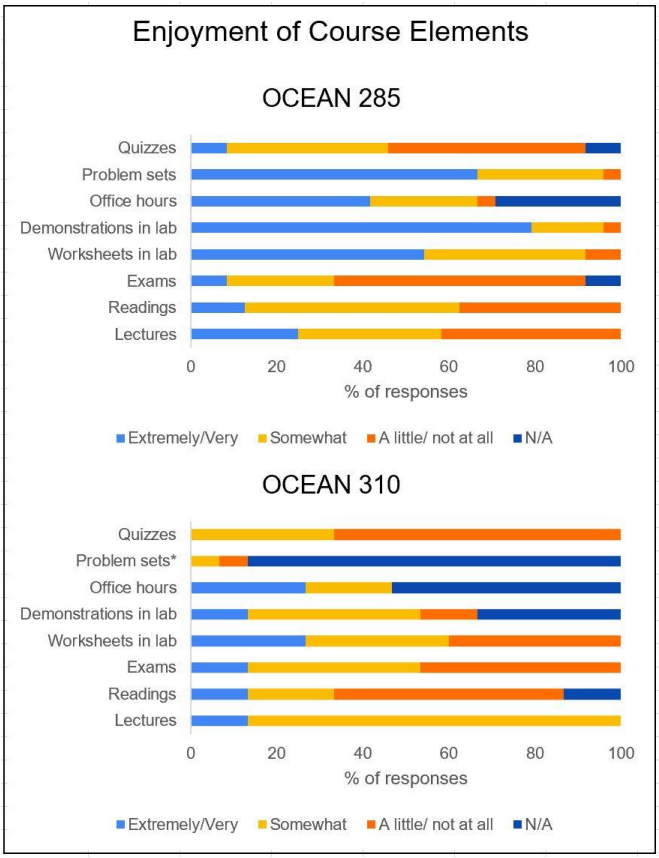

Figure 3. Survey responses of enjoyment of course elements in A) Fluid Mechanics and Waves (OCEAN 285, n=25) and B) Marine Geology and Geochemistry (OCEAN 310, n=14) in Autumn of 2020. In panel A and B light blue represents extremely and very enjoyable, yellow represents somewhat enjoyable, orange represents a little/not at all enjoyable, dark blue indicates that students identified the course element as Not applicable

**Course element not present in course*

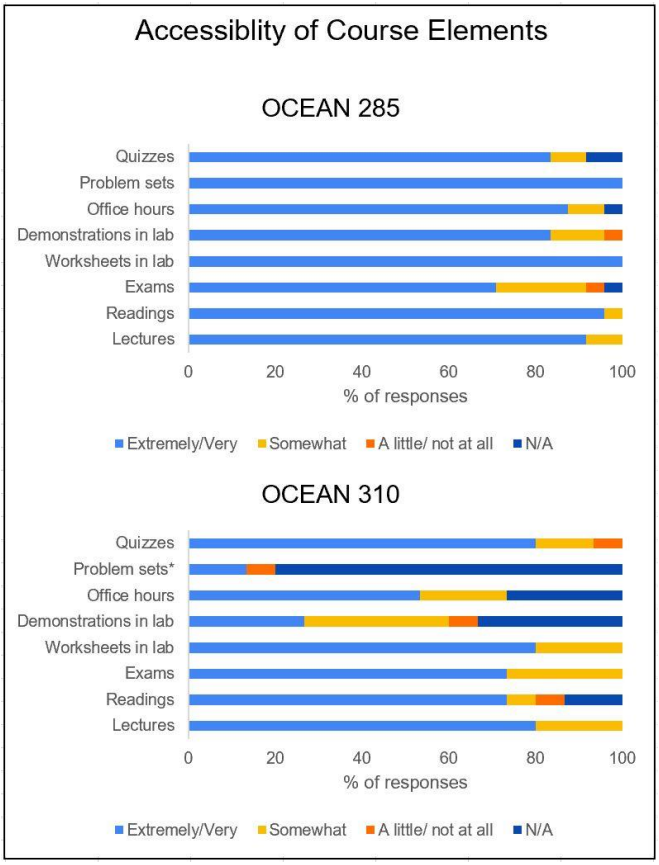

Figure 4. Survey responses of accessibility of course elements in A) Fluid Mechanics and Waves (OCEAN 285, n=25) and B) Marine Geology and Geochemistry (OCEAN 310, n=14) in Autumn of 2020. In panel A and B light blue represents extremely and very accessible, yellow represents somewhat accessible, orange represents a little/not at all accessible, dark blue indicates that students identified the course element as Not applicable

**Course element not present in course*

Course evaluations

Course evaluation scores lowered in 2020 in the categories of Course as a whole, overall, and CEI for OCEAN 285 (Table 5). Course evaluation scores lowered in 2020 in the categories of Course as a whole, and overall for OCEAN 310 (Table 5). Course evaluation scores were higher in 2020 for CEI for OCEAN 310 (Table 5)

Table 5. Course evaluation scores averaged across 2016-2019 and from 2020 for Fluid Mechanics and Waves (OCEAN 285), a course with a flipped course structure starting in 2020, and Marine Geology and Geochemistry (OCEAN 310). "Overall" provides an overall index of the class's quality (1-5, 5 being the highest). "Challenge and Engagement Index" (CEI) combines student responses to several items relating to how academically challenging students found the course to be and how engaged they were (1-7, 7 being the highest)

	OCEAN 285		**OCEAN 310**	
	2016-2019	2020	2016-2019	2020
Overall	4.7	4.5	4.4	4
Course as a whole	4.4	4.1	4.3	3.5
CEI	5.4	5.2	4.9	5.2

Discussion

Students in OCEAN 285 had significantly higher grades than in previous years of the course, some of which may be due to the course structure of OCEAN 285 being changed to a flipped course while taught online. In OCEAN 285 the main element of the course that contributed to student learning was the problems sets, which as a flipped course were the main learning component and what the course was focused on. These problem sets had a very high percentage of students that identified them

as extremely effective in contributing to their learning. 66% of students also indicated that the problem sets were extremely or very enjoyable which may contribute to students' perceptions of their effectiveness. There are other factors in OCEAN 285 that impacted how high the grades of the course were- not having a midterm that contributed significantly toward overall grades likely inflated the grades of students although a closer look at the individual components grades of students would need to be done to confirm this. Because students were guided through problem sets with the help of other students and TAs during course, time and not completed outside of the course it is likely that this raised the grades of the problem sets.

The overall course evaluation score was lower in OCEAN 285 relative to previous years, by about 0.2 indicating that students did not rank the course as highly as they did in the past. The course as a whole section also went down, which is another indicator that overall students were not as satisfied with this course as they have been in the past. The score for challenge and engagement also went down for this course, this could indicate that students were either less engaged in the course as it compares to other courses, or that they found it less difficult than students did in the past. The format for this course included engagement with other students and with the material constantly, so it is probably more likely that the difficulty level of this course was perceived as less than previous year. But since this metric is a combination it isn't possible to identify which component contributed to the change. The CEI score is also related to all of the courses that are similar that are taught in the same quarter, so it could be that other courses that students took were harder than this one.

In OCEAN 310 the primary course element was lecture that students attended each day, and the lecture component in OCEAN 310 did have a higher percentage of students that found them extremely and very effective than the lectures of 285. However, if the main course elements from 285 (problem sets) and 310 (lectures) are compared, the lectures were less effective than the main component of OCEAN 285. About 13% of students indicated that lectures were extremely or very enjoyable, the rest of

students indicated that they were somewhat enjoyable. The course element being less enjoyable for students could affect how students perceive the effectiveness of lectures in OCEAN 310. The average and median grades in OCEAN 310 remained about the same, but did decrease by 0.1 on a GPA scale. The overall distribution for OCEAN 310 remained about the same as well, so regardless of all other metrics students did perform about the same in AU20 as they did in previous years in this course.

The overall course evaluation score for OCEAN 310 went down by 0.4 in 2020 compared to the average of previous years, this could indicate that students were not as satisfied with this course as they were in previous years and the change in OCEAN 310 was greater than in OCEAN 285. The same is true with the course as a whole metric for OCEAN 310, students scored the 0.8 lower as compared to 0.3 lower in OCEAN 285. The most interesting is that while the CEI score went down for OCEAN 285, it went up for OCEAN 310 by a score of 0.3. This indicated that students either found the course more difficult or more engaging as compared to other courses in AU20. Again, the exact reason why this score has changed cannot be ascertained but it is likely that students found OCEAN 310 more difficult than in previous years. A recent study also found that, in general, students are ranking courses that underwent an online transition in response to COVID-19 lower than in previous years all around (Garris and Fleck, 2020).

Overall in the online setting, students in OCEAN 285 received higher grades, indicated that the effectiveness of the main course element as being extremely effective, and the course evaluation scores went down less than OCEAN 310. In the online environment flipped courses may be more effective than traditional structured courses in teaching upper division oceanography, as this study indicated. This study largely fits into the greater body of work that shows that flipped course structures can improve student performance in courses (O'Flaherty and Phillips, 2015; Unal and Unal, 2015). And begins to show that Oceanography courses do not differ from other subjects in this regard, but more work is required to understand the extent of this effectiveness.

Conclusion

Course structures are an essential factor that influences how well students perform in courses, and should be studied to better understand how to create more effective courses for students. Previous studies showed that flipped courses were effective across a variety of disciplines and this study was designed to assess if upper division oceanography courses could also be improved using this structure. This studied showed that a flipped course structure could be effective when implemented in oceanography courses, but more research is needed to determine how effective structure would be in an in person setting. Moving forward, it would be beneficial to study how effective the same course taught in two different course structures is to better control the variables that are introduced by studying two different courses.

Acknowledgements

Thank you to my advisors Dr. Mark Warner and Dr. Mikelle Nuwer for all of their help throughout this process, as well as Dr. Susan Hautula and Dr. Evan Solomon and for allowing me to study their courses. Thank you to Leland Wood for helping me write the code needed for this project.

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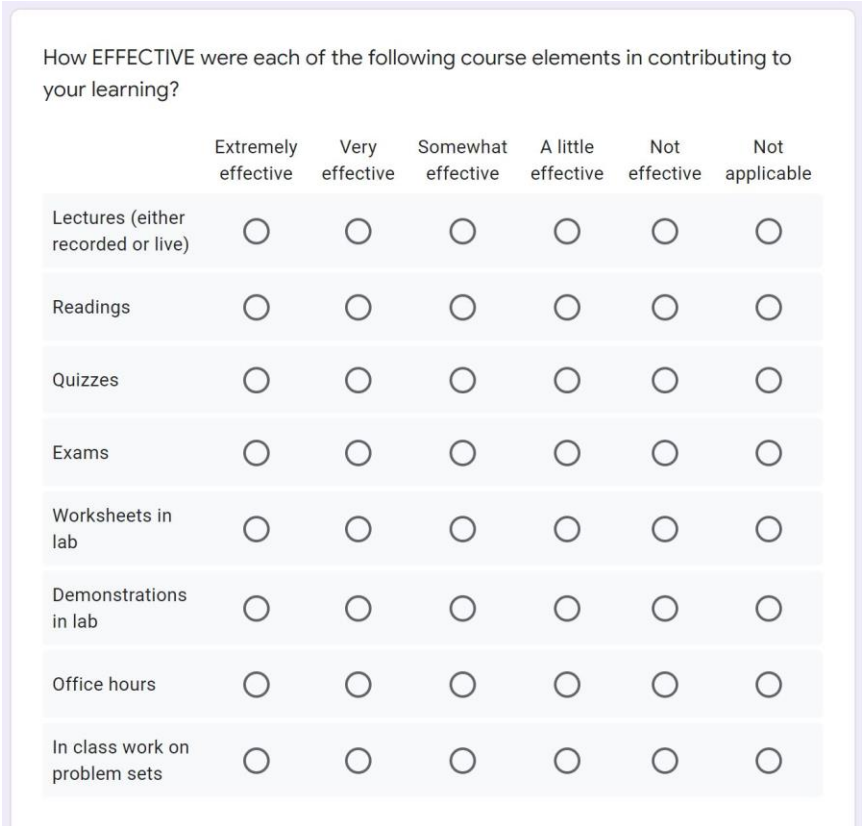
Appendix

Appendix 1- UW Standard Grading System

Letter Grade	Number	Note
A	4.0-3.9	
A-	3.8-3.5	
B+	3.4-3.2	
B	3.1-2.9	
B-	2.8-2.5	
C+	2.4-2.2	
C	2.1-1.9	
C-	1.8-1.5	
D+	1.4-1.2	
D	1.1-0.9	
D-	0.8-0.7	Lowest passing grade.
E	0.0	Academic failure. No credit earned.

Appendix 2- Survey Questions


How EFFECTIVE were each of the following course elements in contributing to your learning?

	Extremely effective	Very effective	Somewhat effective	A little effective	Not effective	Not applicable
Lectures (either recorded or live)	○	○	○	○	○	○
Readings	○	○	○	○	○	○
Quizzes	○	○	○	○	○	○
Exams	○	○	○	○	○	○
Worksheets in lab	○	○	○	○	○	○
Demonstrations in lab	○	○	○	○	○	○
Office hours	○	○	○	○	○	○
In class work on problem sets	○	○	○	○	○	○

How ENJOYABLE were each of the following course elements for you personally in this course?

	Extremely enjoyable	Very enjoyable	Somewhat enjoyable	Not enjoyable	A little enjoyable	Not applicable
Lectures	○	○	○	○	○	○
Readings	○	○	○	○	○	○
Quizzes	○	○	○	○	○	○
Exams	○	○	○	○	○	○
Worksheets in lab	○	○	○	○	○	○
Demonstrations in lab	○	○	○	○	○	○
Office Hours	○	○	○	○	○	○
In class work on problem sets	○	○	○	○	○	○

How ACCESSIBLE were each of the following course elements?

	Extremely accessible	Very accessible	Somewhat accessible	Not accessible	A little accessible	Not applicable
Lectures	○	○	○	○	○	○
Readings	○	○	○	○	○	○
Quizzes	○	○	○	○	○	○
Exams	○	○	○	○	○	○
Worksheets in labs	○	○	○	○	○	○
Demonstrations in lab	○	○	○	○	○	○
Office Hours	○	○	○	○	○	○
In class work on problem sets	○	○	○	○	○	○

Appendix 3- Human Subject Division determination

UNIVERSITY of WASHINGTON
HUMAN SUBJECTS DIVISION

NOT RESEARCH

January 5, 2021

Dear KENNEDY CAMERON:

On 1/5/2021, the University of Washington Human Subjects Division reviewed the following application:

Type of Review:	Initial Study
Title of Study:	Effectiveness of flipped vs traditional course structures in upper division oceanography courses
Investigator:	KENNEDY CAMERON
IRB ID:	STUDY00012222
Funding:	None
IND, IDE, or HDE:	None

The Human Subjects Division determined that the proposed activity is not research, as defined by federal and state regulations. Therefore, review and approval by the University of Washington IRB is not required.

This determination applies only to the activities described in this application. **Depending on the nature of your study, you may need to obtain other approvals or permissions to conduct your activity. For example, you might need to apply for access to data or specimens (e.g., to obtain UW student data). Or, you might need to obtain permission from facilities managers to conduct activities in the facilities (e.g., Seattle School District; the Harborview Emergency Department).**

If you need to make changes in the future that may affect this determination or are not sure, contact us or submit a new request for a determination. You can create a modification by clicking Create Modification within the study.

We wish you great success.

Sincerely,

Tasha Mikko, MSW
IRB Administrator – Committee D
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