An Analysis of Student Preferences for Inverted vs Traditional Lecture

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Abstract

The benefits of inverted lectures are well documented, including improved retention and a focus on active, student-directed learning. However, not all students prefer the inverted lecture model. In this study, we provided students with both inverted and traditional lectures in the same introductory CS course. Students were asked to attend both styles of lecture, and at the end of the course, they were asked to compare the lectures to each other as well as to other course components such as assignments and readings.

Analyzing the responses of 243 students, we found no obvious preference trend with respect to grades. However, we did find a preference for traditional lectures among international students, as well as a very strong preference for inverted lectures among female students.

1. Introduction

Inverted or “flipped" classrooms are very popular in large introductory computer science courses, and have been shown to benefit students by improving engagement and focusing the classroom on student centered learning(Horton, Craig, Campbell, Gries, & Zingaro, 2014; Strayer, 2012). However, there are down-sides to inverted lectures as well, and the inverted lecture format may not appeal to, or be appropriate for, all types of students(Abeysekera & Dawson, 2015; Mason, Shuman, & Cook, 2013; Gannod, Burge, & Helmick, 2008).

In this study, we offered students a hybrid course, with both inverted and traditional lectures simultaneously covering the same material. Students were encouraged to attend both lecture types, but no marks in the course were directly tied to attendance. At the end of the course, students were asked to rank the various course components and choose those which they felt were most beneficial to their learning experience. This gave us an opportunity to directly compare student perceptions of the lecture styles on their own educational development.

Our initial hypothesis was that the inverted lecture model would be particularly beneficial to students who were otherwise struggling with learning to program and finding the core content overwhelming, and therefore that we would see a discrepancy in preference for lecture type by final course grade. We also believed that female identifying students would be more likely to appreciate the interactive and interpersonal nature of the inverted lectures, and that we would therefore see a corresponding preference for inverted lectures among female students. Finally, we believed that our international student population, who anecdotally reported having less group work and discussion based classes in their academic history, would display a corresponding preference for traditional lecture over the inverted model.

We therefore have the following research questions for this study:

- RQ1: Do lecture preferences vary by course grade?
- RQ2: Is there a difference in lecture preference by gender?
- RQ3: Is there a difference in lecture preferences among international students?

To form our initial hypotheses, we used anecdotal evidence and personal opinions of the authors.

Our initial hypotheses, based on anecdotal evidence and personal experiences are as follows:

- H1: There will be a negative relationship between final course grade and preference for inverted lectures.
- H2: Female identifying students will show an increased preference for inverted lectures.
- H3: International students will show a decreased preference for inverted lectures.

These hypotheses were validated through discussion of past experiences and anecdotal evidence among the teaching team and teaching assistants for the course. While there was some disagreement as to the hypothesised causes and effect sizes, particularly with respect to our international students (discussed further in Section 5.1), there was a general agreement that these were the most likely expected outcomes.

The development of the semi-inverted course model, where students simultaneously take traditional and inverted lectures on the same core material was also an interesting experience. Therefore, in Section 3, we provide a brief experience report of developing the course, along with some of the pedagogical decisions and constraints that may have impacted the study.

All of the worksheets and lecture slides used in this course are available for anyone who wishes to attempt to replicate this study, or to implement this classroom model themselves at `https://uoft.me/PPIG2020`.

2. Background

The use of the inverted classroom as a method of teaching, sometimes referred to as a 'flipped classroom', has increased in popularity in recent years. In 2013, 29% of higher education faculties in the United States had implemented some form of inverted learning and 27% were planning to do so according to (Bart, 2013). A substantial amount of existing research is available detailing the methodologies and implementations of inverted classroom (Aliye Karabulut-Ilgu & Jahren, 2018). The modern resurgence of inverted classroom is largely technologically focused, with content being distributed online (Lockwood & Esselstein, 2013).

Inverted classrooms have previously been shown to increase collaboration and discussion between students (Herold, Lynch, Ramnath, & Ramanathan, 2012; Strayer, 2012) with an increase in active learning (Mason et al., 2013; Timmerman, Raymer, Gallgher, & Doom, 2016), and improved student outcomes (Horton et al., 2014). There are conflicting findings on the effects of inverted lectures on student outcomes. Some studies have found that students in inverted lectures outperform those in traditional classrooms (Ossman & Warren, 2014; Schmidt, 2014; K. Yelamarthi & Drake, n.d.), some found no significant difference (B. Love & Swift, 2014; Mason et al., 2013; Olson, 2014; Swift & Wilkins, 2014; S. B. Velegol & E.Mahoney, 2015), while a few showed that the inverted classes had worse outcomes (J. P. Lavelle & Brill, 2013; Mcclelland, 2013). Inverted lectures introduce some challenges to both instructors and students. A common component of the modern flipped classroom is the distribution of online video lessons covering course content. The increased technical requirements of online videos can add significant overhead to course preparation for the first semester that the course is taught (V. Kalavally & Khoo, 2014; Gannod et al., 2008), but subsequent semesters would have reduced course preparation

time (Herold et al., 2012). Creating high quality videos is time consuming (Stephenson, 2019) and poor quality or inappropriate length videos can have a negative impact on student engagement (Olson, 2014). The inverted lecture can also result in increased interaction demands during the course (R. M. Clark & Besterfield-Sacre, 2014).

Some research has pointed to issues regarding motivation in inverted classrooms. Since the effectiveness of the model is reliant on students completing pre-class assigned work, more time is required for students to watch videos or complete readings prior to lecture, which causes problems for students with poor motivation or time management skills (Abeysekera & Dawson, 2015). Many inverted classroom models use quizzes at the beginning of lecture as a means of forcing students to arrive prepared (Toto & Nguyen, 2009). However, this can lead to increased student anxiety, a diminished sense of trust and a sense of patronizing (Herold et al., 2012; Mason et al., 2013). Some research has shown that students who are used to traditional lecture structures can be resistant to accepting an inverted model, particularly if they arrive from a cultural context where classroom interactivity is less common (Gannod et al., 2008; A. Amresh & Femiani, 2013; Bland, n.d.).

3. Course Structure and Development

In this section, we provide the details of our hybrid model alongside a brief pedagogical explanation of the reasoning behind its development.

The initial goal of our hybrid lecture model was to create a way to run our lectures that had some of the benefits of the flipped classroom, but with a lower barrier to entry. In particular, we wished to see if it was possible to achieve some of the self-direction and student focused learning aspects of an inverted lecture without making major changes to the logistics of the course or needing to develop large amounts of online resources.

A secondary desire was to keep as much of the experience 'in-the-room' as possible, as The University of Toronto Scarborough already has a large commuter community, and we wanted to keep the students focused on being physically present in the classroom, without feeling like they were really working remotely and only coming to class for administrative purposes.

A third goal of the project was to develop a teaching model that was not overly paternalistic; many inverted classroom models have marks awarded for attendance or mandatory in-class quizzes that primarily serve to ensure that students come to lecture. While this may be beneficial for many students, our teaching team felt that students should be treated as adults, and be given as many opportunities as possible to choose their own method of learning and level of commitment.

Prior to the project, the course consisted of three hours of lecture per week, organized into a two hour and a one hour block, on different days of the week. There were also one hour weekly tutorials, run by undergraduate teaching assistants, and drop in practical sessions where students could get help with weekly exercises or class material. The course had two term tests and a final exam as well as three larger programming assignments, weekly exercises and quizzes held in tutorial.

For the hybrid model, we converted one hour of lecture time to an inverted model. So students would still receive two hours of traditional lecture, unchanged from previous course offerings, aside from a reduced amount of live coding examples. The inverted hour covered material from the previous week (this was necessary as some course sections had their 1 hour block earlier in the week than their 2 hour block), and consisted of worksheets that were handed out at the beginning of the hour, and submitted electronically via the MarkUs submission system(Magnin et al., 2012). Each worksheet was worth 0.5% (10 weekly worksheets for a total of 5% of the course grade).

Attendance was not taken in either lecture, and it was possible for students to complete the worksheets without attending the inverted lecture. However, students were informed that sufficient help would be offered during the inverted lecture to guarantee that if they attended and worked during the hour, they would receive full marks on the worksheet. Furthermore, several of the worksheets were specifically

Implement the program outlined on your specification page. Your code must consist of at least one function which raises exceptions for bad input, and global code which calls the function(s) and deals with bad input appropriately. When you think you have everything working properly, swap with your partner, and see if you can find test cases that break their code. If your partner found a test case that breaks your code, fix your code so that it passes the test case. Repeat as necessary until you can't find any more errors. If you still have time remaining, challenge your partner to add extra functionality.

Figure 1 – Example Worksheet Prompt

designed for group work with a think-pair-share model. An example prompt for such a worksheet can be found in Figure 1.

Both traditional and inverted lectures were taught by the same teaching team, with students randomly assigned to lecture sections.

4. Analysis

At the end of the semester, students were asked to pick the top three course components that they found most beneficial to their learning experience, and to rank those components. We had administered a similar survey at the end of the previous year. The survey was completed online in the final week of the term in exchange for a bonus mark on the final exam.

The options available to students were:

- Reading - weekly online readings which were assigned
- Practicals - drop in practical sessions where students could complete weekly exercises, or get help with other programming questions
- Tutorials - weekly in-class tutorials, led by TAs, reviewing topics covered in lecture
- Assignments - three large programming assignments spread throughout the term
- Exercises - weekly programming questions, submitted online and auto-marked
- Inverted Lecture
- Lecture

In the 2015-16 version of the survey, the options were the same except that Inverted Lecture/Worksheet was not available for obvious reasons.

We developed a simple model to compare the results of these surveys, whereby the highest ranked component was given a score of 3, the second highest was given a score of 2 and the third highest a score of 1. Cumulative totals for each component were then computed, and compared as a percentage of total marks allocated.

This "pick your top three" method of relative evaluation was chosen rather than either directly questioning the students as to their preference for traditional or inverted lectures in order to be compatible with previously collected data, and to avoid leading or biasing questions. In pre-study evaluations with a different student group, we found students to be very susceptible to the wording of direct questions: "Did you prefer inverted lectures to traditional ones" vs "Did you prefer traditional lectures to inverted ones", and providing students with a likert scale resulted in most students giving the same or very similar results for all course components.

Table 1 – Participant Demographics

	Total Count	Percentage
Total Participants	243	
Gender		
Female	61	25.1%
Male	154	63.4%
Other/Did not specify	28	11.5%
Student Status		
Domestic	104	42.8%
International	115	47.3%
Unknown	24	9.9%

4.1. Demographics

Out of a total of 264 students enrolled in the course, 243 agreed to participate in this study. 154 students identified as Male, 61 as female, and 28 chose not to specify. 104 of the students were registered as domestic students while 115 were registered as international, 24 students registration status could not be determined. The demographics are summarized in Table 1.

This study did not include racial demographics, but the department's international student cohort overall was drawn 65% from China, 12% from other Asia Pacific countries, 6% from India/Pakistan, 5% from Europe, 6% from other countries in the Americas and 2% from Africa.

4.2. Comparison with Historic Data

A comparison of the point allocation for the course offered prior to the commencement of the project and for the improved semi-inverted version of the course can be found in Figure 2.

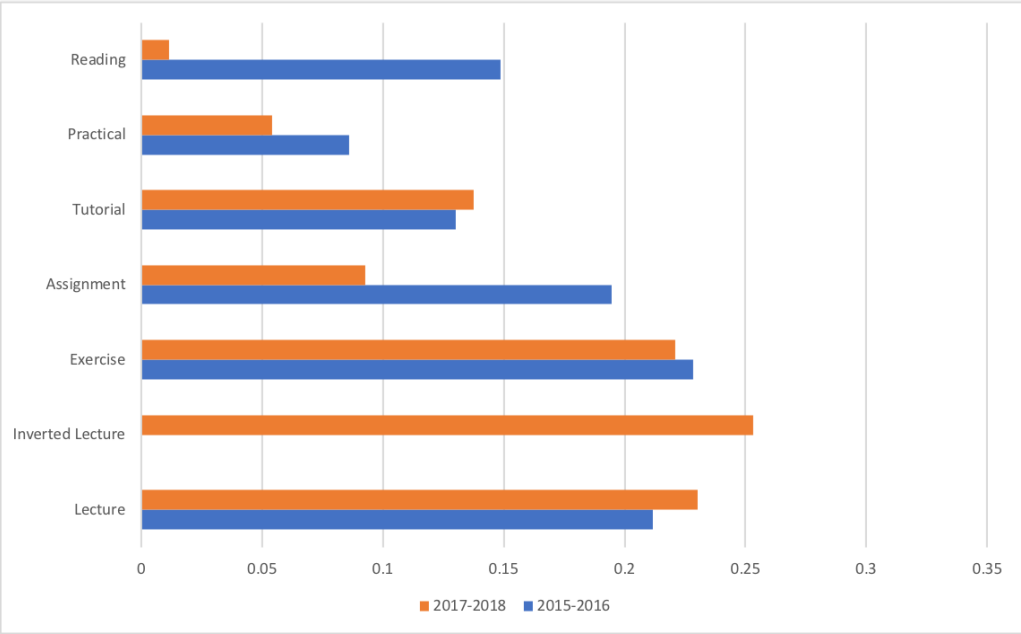

Figure 2 – Student survey results for traditional and semi-inverted offerings

While lectures were always a popular course element, second only to weekly exercises in terms of perceived learning benefit, the inverted lectures immediately became the most popular component, beating out both the traditional lectures and exercises.

Of particular interest is where the points now allocated to the inverted lecture appear to have come from. It would be natural to assume that the points previously allocated to lecture would now be split among the lecture and inverted lecture options. However, it seems that the points allocated to lecture remained relatively constant, whereas the points allocated to assignments dropped significantly and those allocated

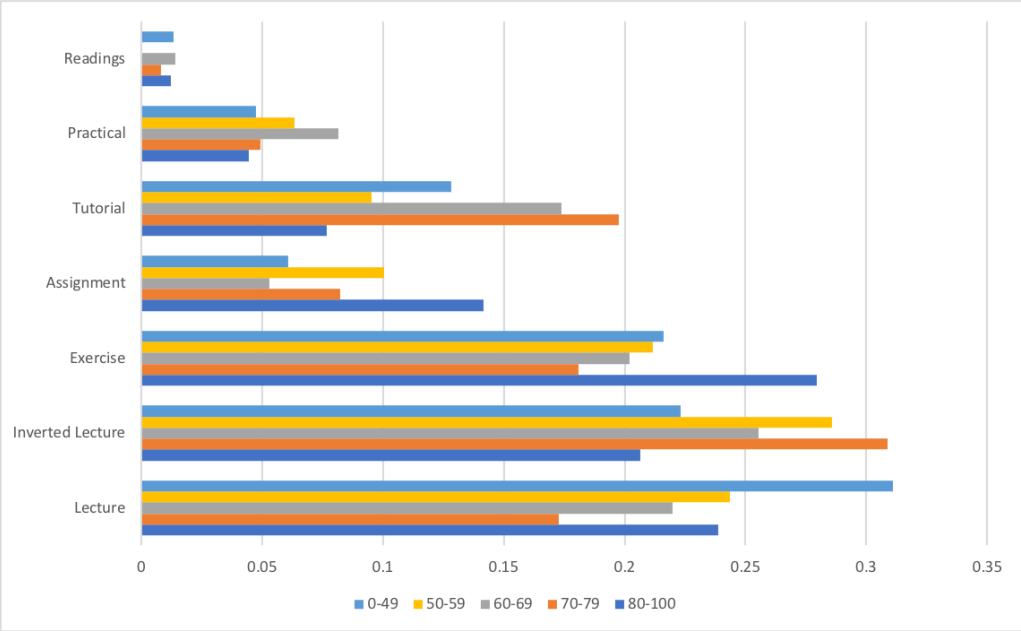

Figure 3 – Student survey results by final course grade

to readings dropped drastically. While it is possible that the assignments points were due to different assignments being used in the two years, the readings were kept constant.

We cannot draw any strong conclusions from the differences between preferences in the two cohorts, due to the course changing and shifting student preferences and attitudes over time. However, comparing the results of our survey to that of previous data indicates that the changes in preferences are likely due to the change in teaching model. Furthermore, this process does provide some insight into the changes in relative perceived importance of various course components.

4.2.1. Course Outcomes and Grades

Due to the difference in the final examination and assignment questions, it was not possible to directly compare course outcomes between the two years. The averages and grade distributions were not significantly different. However, since the graded material and grading scheme changed between years, a direct comparison is not helpful.

4.3. Sub-Group Analysis

While knowing the overall perceived benefits of the inverted lectures is interesting, we wanted to analyze further in order to see if the distributions changed for various sub-groups.

4.3.1. Course Grade

We first checked the distribution of preferences by final course grade. As shown in Figure 3, the inverted lecture appears to be least popular among students at the lower and higher ends of the grade spectrum (those with final marks below 50 or above 80), and more popular with students in the middle of the spectrum. The opposite effect is seen for the traditional lecture, where students in the middle of the grade spectrum responded less favourably than their counterparts. However, this result was not statistically significant, and does not appear to follow any clear trend. We therefore conclude that there was no evidence of a relationship between lecture preference and course outcome ($\chi^2 = 13.9432$, $df = 24$, $p = 0.9479$).

4.3.2. International vs Domestic Students

We next separated the data by international and domestic students. As seen in Figure 4, it appears that domestic students believed the inverted lecture was more beneficial than the traditional lectures, their international peers had the opposite opinion.

The differences between the two groups was not large, and after performing a Pearson's chi-squared test with Yates' continuity correction based on the number of students putting inverted lecture in their top three components, we found no statistically significant difference ($\chi^2 = 0.061719$, $df = 1$, $p = 0.8038$).

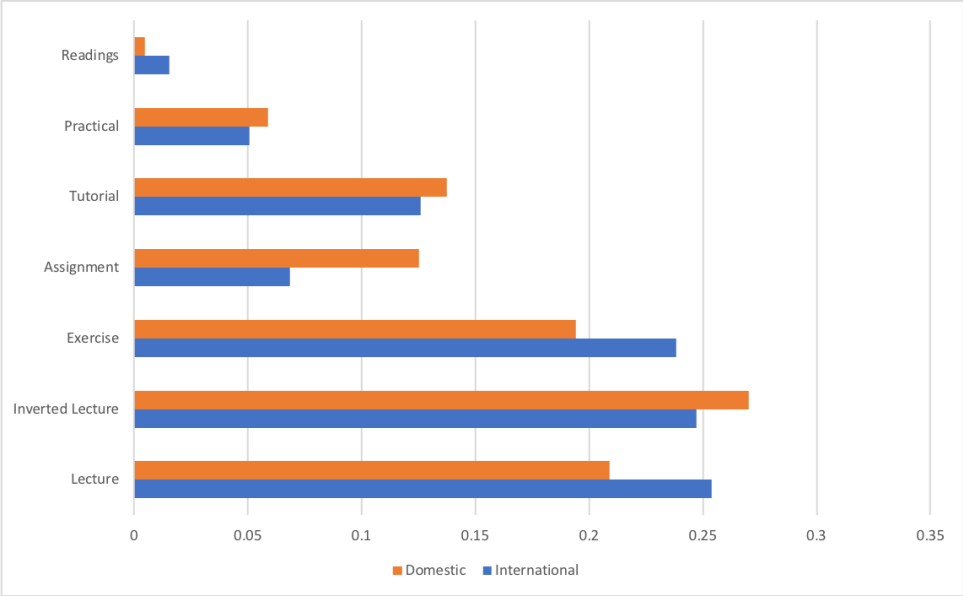

Figure 4 – International vs domestic student survey results

4.3.3. Gender

Grouping the data by gender produced very interesting results, as can be seen in Figure 5. Most of the course components were fairly closely ranked, but the traditional lecture was perceived as more helpful by male students, with the inverted lecture being ranked much more highly by female students. 62.3% of female students had inverted lecture as one of their top three components, compared to only 42.9% of males. Running a Pearson's chi-squared test with Yates' continuity correction based on the number of students putting inverted lecture in their top three components showed that there was in fact a statistically significant difference ($\chi^2 = 5.8551$, $df = 1$, $p = 0.01553$).

5. Conclusions and Future Work

In this study, we analyzed the student preferences for traditional vs inverted lectures. By developing a hybrid model which allowed students to simultaneously participate in both lecture types, covering the same core material, we were provided with a unique opportunity for direct comparison.

We found that students overall found the inverted lectures useful, pushing readings and assignments out of many of their top three course components. And while there was not conclusive data of the effect of the introduction of these lectures on student outcomes, that was beyond the scope of this project, and has been well studied elsewhere.

As for our primary research questions, we found the following results:

- **RQ1: Do lecture preferences vary by course grade?**
  While there were slight differences in preference at various grade levels, there was no clear pattern, and the results were not statistically significant. We must therefore conclude that there is no evidence of a correlation between course grade and lecture preference.
  H1: Our hypothesis was not supported.

- **RQ2: Is there a difference in lecture preferences among international students?**
  International students did show more of a preference for traditional lecture, while domestic stu-

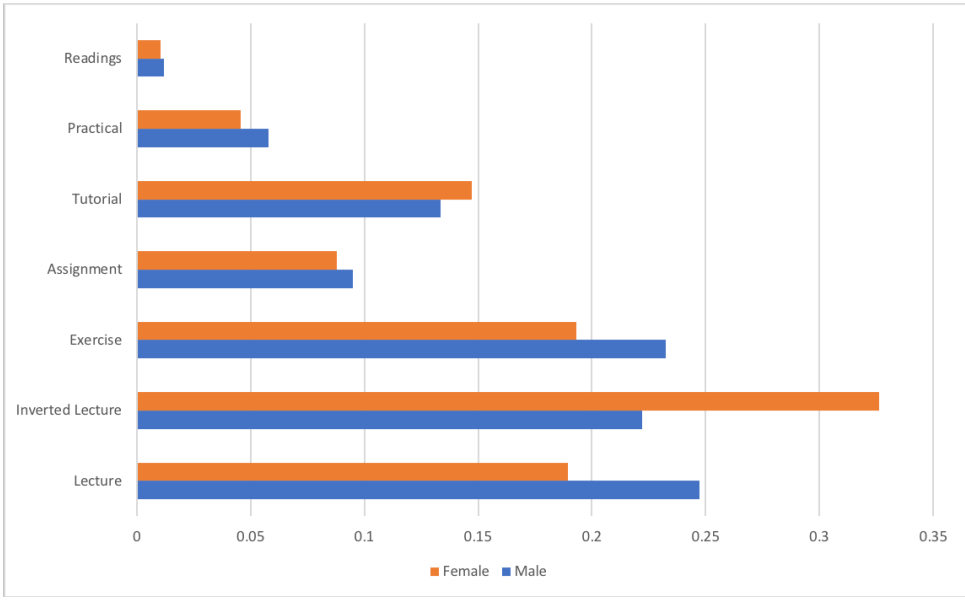

Figure 5 – Male vs female student survey results

dents ranked inverted lectures higher. However, this result was not found to be statistically significant.
H2: Our hypothesis was not supported.

- **RQ3: Is there a difference in lecture preference by gender?**
  There appears to be a quite large and statistically significant difference in preferences by gender, with females showing a marked preference for inverted lectures over the traditional model, while their male colleagues showing a slight trend in the opposite direction.
  H3: Our hypothesis was strongly supported.

In addition to allowing for interesting research findings, the hybrid model appears to have achieved its original goal of allowing for a low barrier to entry method for obtaining many of the benefits of inverted classrooms, without many of the drawbacks. We intend to maintain this hybrid model in future and hope to replicate this study, while improving the learning experience of our students.

5.1. Threats to Validity

This experiment was conducted on a single cohort of students at a single institution. Therefore the results should not be assumed to extrapolate to a global context without further research.

Reasonable attempts were made to control relevant variables in the course. The teaching team remained constant, with the same instructor teaching both sets of lectures with the same material in both the experimental and comparison years. However, it is entirely possible that some of the results could be attributable to the course or the instructors themselves. While we have provided all our course materials at the link given in the introduction, it is entirely possible that these results are indicative of preferences for our particular method of running inverted lectures, and would have been different for a different teaching team or lecture setup.

We have identified several threats to the validity of the study, which could also be the basis for future studies with more clearly refined controls.

Validity of Survey Results:
The primary purpose of the survey was to ask for student feedback in order to improve the course. While it is reasonable to assume that students would want to respond honestly, as it may affect future courses during their time at the university, it is possible that students could answer dishonestly.

Comparison across Cohorts:
Comparing survey results of the 2017-2018 cohort with those of the 2015-2016 cohort is naturally problematic as this is not a controlled environment, and it is possible that shifts in the student body or course instruction could have a major impact on the result we see in Figure 2. In future studies, we would like to more closely control for these factors and see if the results replicate.

Treating International Students as a Single Demographic Group:
This was a very contentious matter among the research team, as we only had authorization to collect international student status, and not more salient information such as country of origin, level of English proficiency, or pedagogical history. We ultimately decided to report on this data, because we had heard many anecdotal reports that our international student body, especially those from China and Asia-Pacific (who make up 77% of our international students), do not like inverted models. In future studies, we would like to produce a much more nuanced survey, focusing less on fee status, and more on linguistic and pedagogical history.

Survey Design - Using perceived benefit as a proxy for preference.
There are limitations to our "pick your top 3" model. However, it was chosen to be consistent with previous data, and to be as simple and easy to answer as possible. We report our results as preference, while the question itself asks which components students felt benefited them the most. In future studies, we could split this question to specifically ask which components students enjoyed most and which they felt they learned from the most, as it's possible those two concepts are not directly linked.

Many of these threats to validity come from the simple fact that the primary goal of this project was to obtain naturalistic feedback on a pedagogical development. While all reasonable precautions were taken to ensure threats were mitigated, pedagogical development was our main concern. Future work will be needed in order to validate these results. However we feel that this work provides a model for future study and an interesting data point providing evidence of a difference in gender preference.

5.2. Data Availability
All of the relevant material for this project can be found at `https://uoft.me/PPIG2020`.

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