IMPROVED STUDENT LEARNING EXPERIENCE IN LARGE PROGRAMMING CLASSES USING PSEUDO-FLIPPED METHOD

Ritu Chaturvedi

University of Guelph, Ontario, Canada

ABSTRACT

In an effort to improve student engagement in large programming classes, this study pro- poses a pseudo-flipped (PF) method of teaching that combines the core principles of two popular teaching methods, traditional and flipped (or inverted), thereby mitigating the drawbacks of these methods. In traditional teaching, class time is mostly used by instructors to teach a class using pre-prepared lecture slides and smartboards or similar alternatives, whereas students, mostly passively, listen to the lecture and take notes. In a purely flipped class, all resources traditionally taught in classroom are moved outside the classroom, either as text, video, audio, students are expected to read or view lectures before class, and the instructor uses class time in solving problems. In the proposed PF method, students are taught in a traditional way for half the allocated time. For the other half, students solve problems in class with the instructor's assistance. Similar to the flipped method, in PF, students learn concepts on their own outside the classroom using an interactive textbook. To fill gaps in their knowledge, instructors spend time teaching those core concepts in class by solving problems. PF promotes active learning by engaging students towards solving problems on learnt concepts. A survey is done in a pro- gramming class to find student opinion on how useful this pseudo-flipped method is on student engagement as opposed to traditional teaching. Both quantitative and qualitative analysis of the survey responses strongly favour the proposed method, with more than 70% of students in favour of it.

1. INTRODUCTION

Instructors use a variety of methods to improve student learning experience, especially to keep students engaged in classrooms (e.g. use of discussion groups) [4]. Teaching programming to large classes (typically 250 – 300 students) is particularly challenging in terms of student engagement. With increased availability of technology in classrooms, instructors are motivated to use technology in their teaching methods to improve student learning. One such methodology is called inverted or flipped classroom [2, 7]. In a purely flipped classroom, instructors assign the class lecture, typically videos or text, as homework. In preparation for class, students are required to view or read the lecture outside and before the class, whereas the time in class is utilized to work through problems, so that students can engage in learning the concepts at a deeper level in class. A purely flipped classroom method is found to increase student engagement, but is also met with some skepticism [6, 9]. For example, students who are new to programming do not appreciate the idea of independent learning – most of them like the traditional method where course concepts are taught in class by teachers. Realizing the importance of active learning[10], this research proposes a hybrid method that combines the core ideas of traditional and flipped classroom methods and calls it as the "Pseudo-Flipped" method of teaching. This method promotes active learning (similar to flipped method), but it has additional advantages. Firstly, course content is still taught by an instructor, relieving students of the responsibility of learning the content on their own. Secondly, it uses scaffolding [5] of a different level - it helps students who are less prepared and need it most (unlike the flipped method). A detailed comparison of the traditional, flipped and the proposed

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pseudo-flipped methods of teaching is presented in table 1.

2. PSEUDO-FLIPPED (PF) METHODOLOGY

Research Question: What is the impact of using "pseudo-flipped method" to teach large Programming classes on students learning experience in comparison to traditional non-flipped classroom method?

2.1. Participants

All students enrolled in a first-year "Introduction to Programming" course in Fall 2019 and Winter 2020 were invited to participate in the study. Ninety six percent (96%) students consented to participate in the survey in Fall 2019 (256 / 261), whereas 60% consented in Winter 2020. Invitations were sent via e-mail first, and then students were allotted time during a lab session to fill in an anonymous online survey about their experiences with the traditional and pseudo-flipped methods (described in section 2.2). The survey was accessible directly through the course learning management system [3].

2.2. Survey

The surveys were anonymous and were administered by the University's educational analysts until the term was over, as required by the University's ethics board. Invitations were sent via e-mail first, and then students were allotted time during their lab sessions to fill the survey.

Due to time constraints, students in Fall 2019 filled a single survey with 11 questions in it (as shown in table 2). The survey was approximately 15 minutes long and students were given an incentive bonus of 3% to complete the survey. The survey began with a consent letter outlining the study details. Those students who did not consent to participating in the survey were given an alternate quiz, also worth 3%. To be fair, this quiz was open for practice to the entire class after the survey was closed. Although the online survey asked general questions about student's background, this study focused on their responses to eleven questions on their perception and experience in a pseudo-flipped classroom verses a traditional classroom. A 5-point Likert scale was used for ten questions (Q1- Q10) asked in the survey (ranging from "Definitely Yes" to "Definitely not" or from"Never" to "Always"); question Q11 had just 2 choices "Traditional" or "Pseudo-flipped".

Students in Winter 2020 filled 2 surveys in the term - survey I was given in week 4, whereas survey II was given in week 11. Survey I and II questions are listed in Table 3 for reference. Each survey was approximately 15 minutes long and students were given an incentive bonus of 1.5% to complete each survey. The survey began with a consent letter outlining the study details. Those students who did not consent to participating in the survey were given an alternate quiz, also worth 1.5%. To be fair, the alternate quiz for each survey was open for practice to the entire class after the survey was closed. Although the online survey asked general questions about student's background, this study focused on their responses to eleven questions on their perception and experience in a pseudo-flipped classroom verses a traditional classroom. A 5-point Likert scale was used for ten questions (Q1- Q10) asked in the survey (ranging from "Definitely Yes" to "Definitely not" or from"Never" to "Always"). Question Q11 had just 2 choices "Traditional" or "Pseudo-flipped".

	Traditional	Flipped	Proposed Pseudo-Flipped
Teaching	Class time is mostly used by instructor to teach the class using lecture slides and black board or similaralternatives. [3]).	All resources traditionally taught in classroom are moved outside the classroom, as text, video oraudio. Students are expected to read or view lectures before the class time. [2]	The 3-hours assigned eachweek for teaching a courseis divided as 1.5 hours of traditional teaching AND 1.5 hours of flippedteaching model.
Learning	Learning is mostly passive Students are expected tolisten to the lecture, take notes and so on.	Entire class time is spent solving problems. Promotes active learning [10]- is effective only if thestudents have done their part of learning the material before class.	Promotes active learning [10]. Half the time is spenton teaching content, otherhalf spent actively on guiding students when solving problems.
Pre-Requisites	Pen and paper to take notes.	Students are required to learn the material before class. Also requires a heavy use of technology.[1]	Pen and paper to take notes and work on problems in class. Requirestechnology.
Drawbacks	Passive learning - students don't get a chance to learnto apply concepts to different problems with theteacher's help or collaboratively.	The onus is a lot on students - not all studentsare good with time management and with independent learning.	Reduced lecture time. Students may feel safe to skip classes used to solveproblems.
Advantages	Teacher teaches every required content in class - takes the load off students.	Promotes Active Learning.	Promotes Active Learning. Scaffolding is of a differentlevel - helps students who are less prepared. Scaffolding has been provwn to be an effective method for educating [5]

Table 1: Comparison of Pseudo-flipped with traditional, and flipped teaching methods

#	Question
1	Did you find the lectures done in class each week relevant to the course learning outcomes?
2	Did you find the worksheets done in class each week engaging?
3	Did you enjoy the worksheets done in class each week?
4	Did you feel that reading ahead from the textbook helped you in understanding the material taught in class?
5	Did you feel that reading ahead from the textbook was helpful in solving assignment problems?
6	Did you feel that doing worksheets in classroom helped your ability to program (write code)?
7	To what extent do you think that in-class worksheets improved your learning?
8	Did you feel that you had the teacher's help when solving problems in class?
9	Did you feel that doing in-class worksheets created a collaborative atmosphere in class and helped you know your classmates better?
10	Did you feel that the class time was used in a good way (and not wasted) by solving problems in class using worksheets?
11	Which of the following is a better teaching model for your programming course?

Table 2: Survey questions: Fall 2019

At the end, there was an open-ended question that allowed students to add additional comments. The question was phrased as: "Do you have any additional comments on the benefit or disadvantage of the pseudo-flipped method, particularly on doing worksheets in class?" These comments were analyzed qualitatively, as explained in section 2.2.2.

2.3. Method

In this study, a method that blends the traditional classroom teaching, active learning (inside a classroom) and self-learning (outside class) strategies used in flipped classes is used to teach a first year C programming class in a 12-week Fall 2019 term. It is named as the psuedo-flipped (PF) method of teaching. Classes were scheduled for 1 hour 20 minutes on Tuesdays and Thursdays of each week. The class had 261 registered students at the time the survey was distributed. The required course textbook was an interactive one and students were required to complete activities assigned to them each week - a 10% weight was assigned to the weekly textbook activities. In weeks 1, 2 and 3 of the term, the instructor used the traditional method of teaching using pre-prepared lecture slides, supplemented by demonstrations on how to write and run C programs on the school server and a white board or document imaging camera to write and explain code, typically to explain and demonstrate what goes behind the scenes when a code is run. In weeks 4 to 12, the structure of the classes changed - the instructor used Tuesdays of each week to teach using the traditional method (as explained above). But on Thursday of each week (from week 4 onwards), the instructor came prepared with a worksheet that had problems pertaining to what was taught on the Tuesday of that week - these problems varied from objective-type, tracing-code, completing a given incomplete

#	Week 4 Survey Questions
1	Did you find the lectures-in-classroom done in class each week engaging?
2	Did you enjoy the lectures-in-classroom done in class each week?
3	Did you find the lectures done in classroom each week relevant to the learning outcomesof CIS1500?
4	Did you feel that regularly attending lectures in classroom helped your ability to program (write code)?
5	Did you feel that you had the teacher's help and support during lectures in class?
6	Did you feel that you had your peers / classmates support during lectures in class?
7	Did you feel that the class time was used in a good way (and not wasted) by attendinglectures in class?
8	Did you feel that reading ahead (from zybooks) helped you in understanding the material taught in class?
9	To what extent do you think that working on programming problems in class will keep you more engaged?
10	To what extent do you think that working on programming problems in class will help your learning?

#	Week 11 Survey Questions
1	Did you find the lectures done in class eachweek relevant to the course learning outcomes?
2	Did you find the worksheets done in class each week engaging?
3	Did you enjoy the worksheets done in class each week?
4	Did you feel that reading ahead from the textbook helped you in understanding the material taught in class?
5	Did you feel that reading ahead from the textbook was helpful in solving assignment problems?
6	Did you feel that doing worksheets in classroom helped your ability to program(write code)?
7	To what extent do you think that in-class worksheets improved your learning?
8	Did you feel that you had the teacher's help when solving problems in class?
9	Did you feel that doing in-class worksheets created a collaborative atmosphere in class and helped you know your classmates better?
10	Did you feel that the class time was used in a good way (and not wasted) by solvingproblems in class using worksheets?
11	Which of the following is a better teaching model for your programming course?

Table 3: Survey questions: Winter 2020

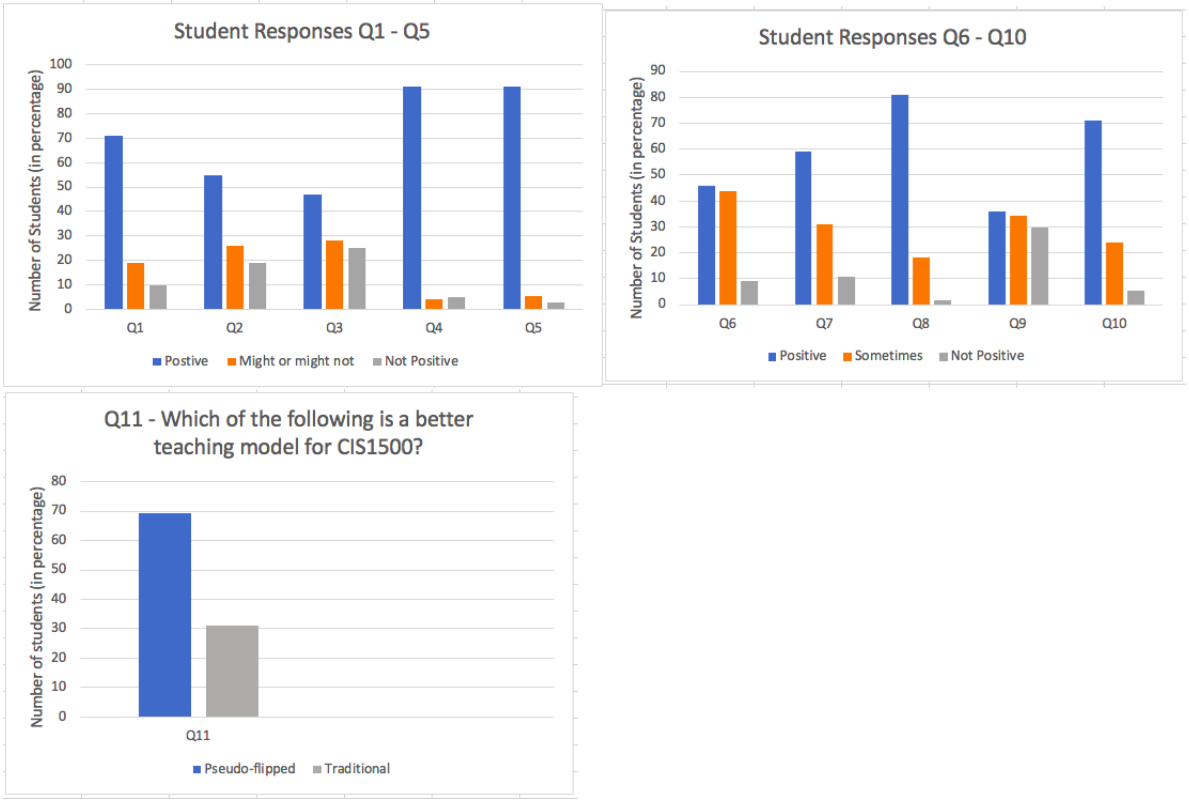

Figure 1: Student Responses for Questions 1 - 11 (in percentage)

code or writing complete code to solve a given problem. Students were give a certain time in class (e.g. 20 minutes) to complete the problems in the worksheet, after which the instructor discussedthe solutions. While the students attempted the worksheet problems, the instructor walked around the class to help students solve those problems. Students were also encouraged to collaborate and discuss with their classmates. In week 11 of the term, students were asked to complete an online survey that had questions on their perspective on usefulness of the proposed pseudo-flipped method on student engagement, on learning the course content and on their ability to write C code to solve problems. This study was approved by the Research Ethics Board at the University.

2.4. Data Cleaning and Transformation

Student responses that were incomplete were removed from the dataset - there were 254 responses (out of 261) that were eventually used in this study. In order to focus only on the positive and negative impact of the proposed method, the categories for all survey questions, was changed from Positive to Negative, and from a 5-point Likert scale to a 3-point scale (Positive, Neutral and Negative). The absolute count of student responses was transformed into percentages for consistency. Graphs in figure 1 show the individual statistics of all survey questions (Q1 - Q11).

	χ^2	df	p-value			χ^2	df	p-value			χ^2	df	p-value
Q1	62	2	< 0.00001		Q5	146	2	< 0.00001		Q9	0	2	1
Q2	20	2	0.000045		Q6	25	2	< 0.00001		Q10	66	2	< 0.00001
Q3	8	2	0.018316		Q7	34	2	< 0.00001		Q11	15	1	.000108
Q4	144	2	< 0.00001		Q8	102	2	< 0.00001					

Table 4: χ^2 and p-values for questions Q1-Q11

2.5. Data Analysis

As a first step, data was collected and managed by a pool of educational analysts, who were not the course instructor, nor was this data divulged to the instructor until January of 2020, after the Fall2019 term was over. Both quantitative and qualitative analysis was performed on the collected data.

2.5.1. Quantitative Analysis

For each question, the null hypothesis (H_0) used was that the student responses have equal distribution in each category (Positive, Neutral and Negative). Table 4 shows χ^2 values and p-values for each question. As can be seen from these values, the result is significant at $p < .01$ for all questions except question Q9. This clearly indicates that the null hypothesis (H_0) can easily be rejected for all questions other than Q9. This is also evident from the graphs shown in figure 1, that the percentage of positive responses was much larger than the negative ones. Graph of question Q11 clearly shows that 70% students spoke in favor of the proposed method. Question Q9 is an outlier as shown in table 4 (its p-value is not significant at $p < .01$) and from the graph in figure 1) and therefore H_0 cannot be rejected for Q9.

2.5.2. Qualitative Analysis

In order to add more context to the quantitative analysis, qualitative analysis [8] was done on the single open-ended comment box given in the survey. These comments were collected and compiled and then coded into different themes, as shown in figure 2. In order to generate the themes, the comments were read several times, crucial words were colour-coded and highlighted, and then themes were induced from them.

Results from Fall 2019 indicate that 70% of students gave positive comments on the proposed pseudo-flipped method - this is very much aligned with the quantitative results of question Q11. The positive comments were further categorized as “Engaging” (15%), “Helpful in learning the course material” (45%) and “Helpful in solving problems” (11%). A handful of students (3%) stated that their comments are not relevant since they often did not attend class. Some students (19%) voiced their opinion or suggestion on the given worksheets (e.g. “worksheets must have more multiple-choice questions” or “more time should be allocated to the worksheets”). These suggestions can be interpreted as a positive comment but this study places them in a different theme called “Neutral” without making any assumptions. There were 8% of students who gave negative comments as shown in the figure. There were some who did not like the idea of writing code on paper (3%), whereas others did not find the worksheets helpful. Some comments had more than one themes reflected in them, although this study chose to place them in only one of the themes. For example, a student

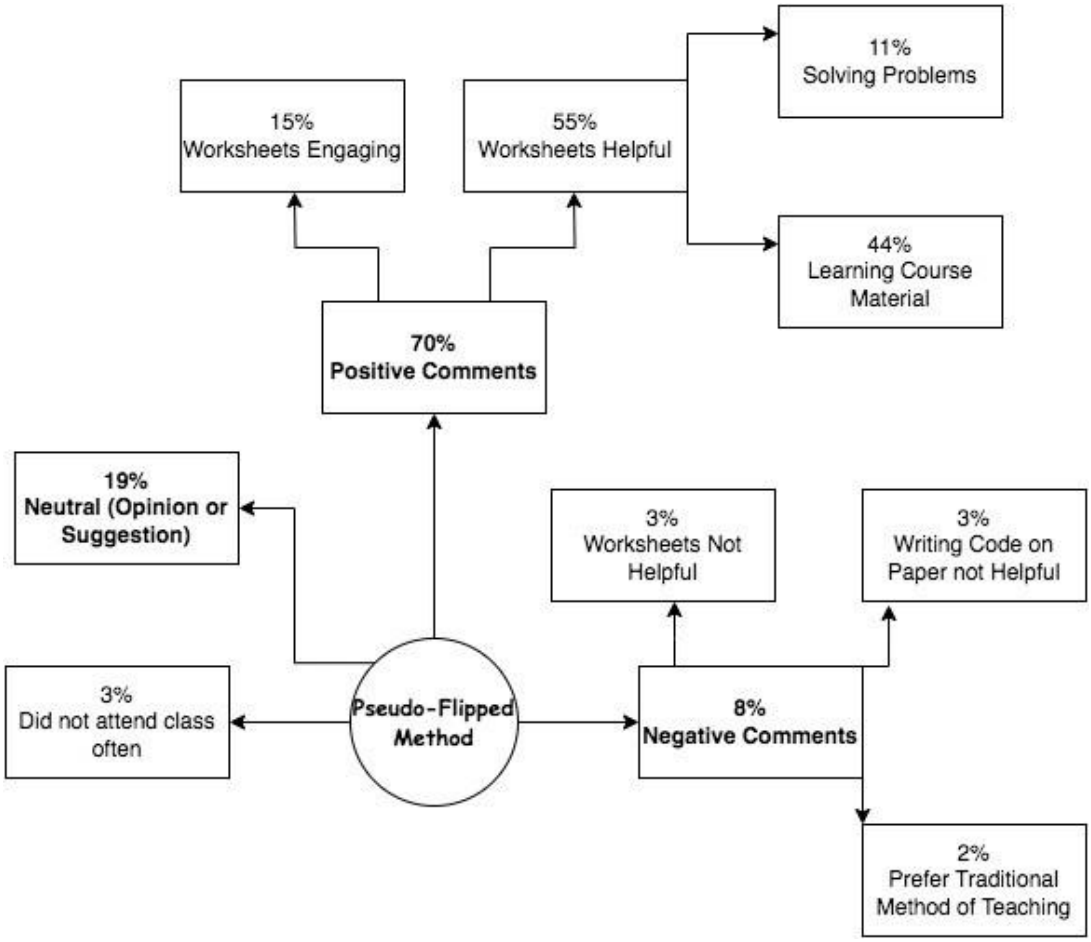

Figure 2: Thematic map resulting from qualitative analysis of open-ended question in Fall 2019

comment "The worksheets worked well as they not only changed the class engaging more students but it helped to see different approaches to problems" could belong to theme "Engaging" and also to theme "Helpful -> Solving Problems", but it was placed in "Engaging" theme only.

Positive comments from students in Winter 2020 was a little lower than Fall 2019 (63% as opposed to 70% in Fall). Most of the themes generated for Winter 2020 were the same as Fall 2019, with an additional two themes namely "Post worksheets in advance" as a sub-theme of "Neutral" comments and "Worksheets were boring" as a sub-theme of "Negative" comments. Figure 3 that presents a thematic map of Winter 2020, in comparison with Fall 2019. The numbers in small rectangular boxes in figure 3 are from Winter 2020.

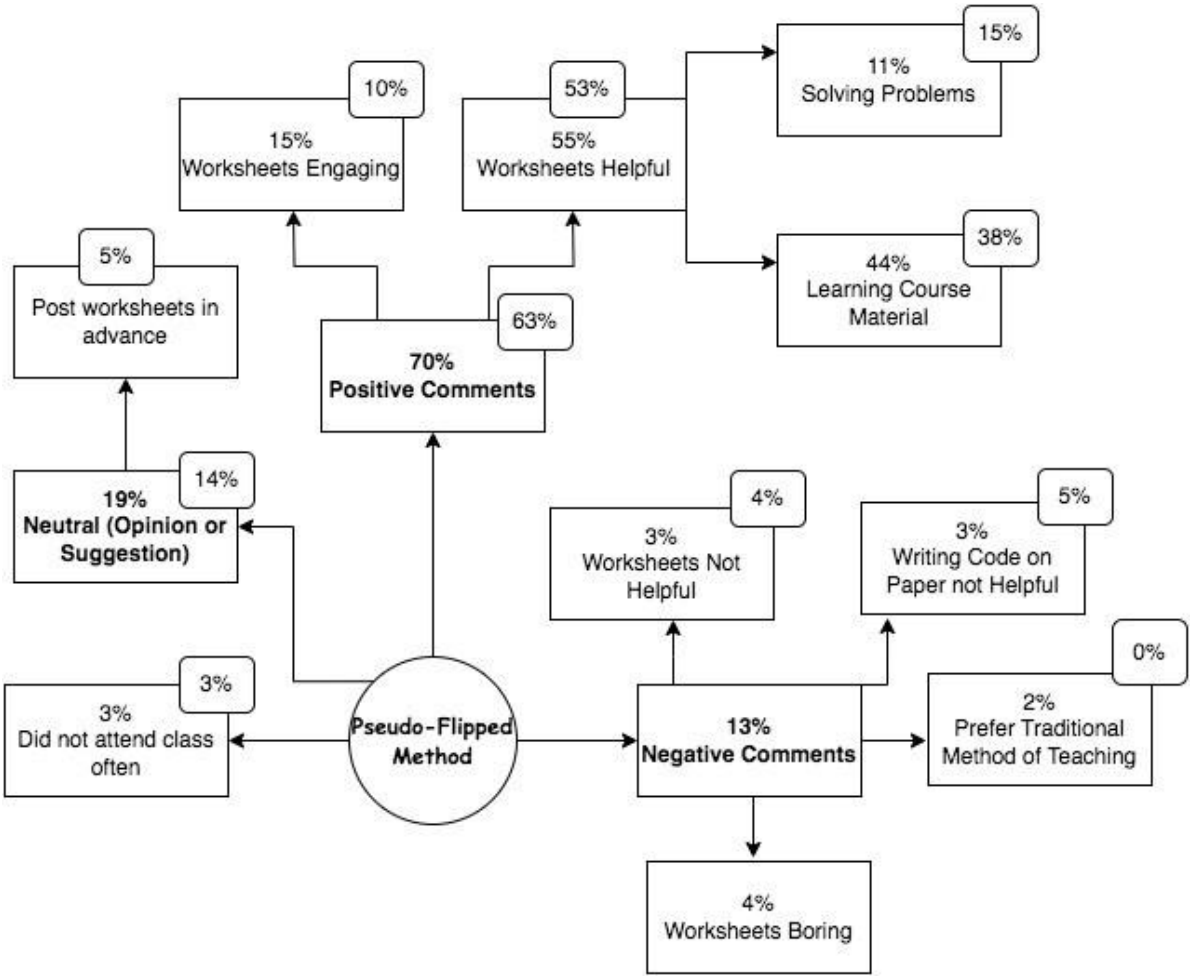

Figure 3: Thematic map resulting from qualitative analysis of open-ended question in Winter 2020, in comparison with Fall2019

3. DISCUSSION AND CONCLUSION

This study was done primarily to improve student experience and engagement in large programming classes. When programming is taught using the traditional classroom method, the communicationis always one-way - from teacher to students. It is a well-known fact that the best way to learn programming is to "do" it. Flipped method of teaching allows students to "do" problems in class and thus, encourages two-ways communication between teacher and students. But for this, students must come prepared to class - they must learn the content before they come to class, for the flipped method to be effective. The challenge for the teacher here is to enforce the "prepare before class" rule. The pressure is more on students to learn the content independently, especially if they are in their first year and this is the first programming class for them. The proposed PF method combines the two core ideas - students are taught the concepts in class, in addition to learning some independently, and they get an opportunity to "do" problems in class with the help of their teacher.

Based on the quantitative and qualitative analysis, an important finding of this study is that students like the idea of solving problem in class because they have the instructor's help in realtime. They valued the instructor's help and support in class, as is evident from the responses of question Q8 of the survey (80% of students responded positively when they were asked "Did you feel that

you had the teacher's help when solving problems in class?", 18% were not sure and 2% said "No"). The study also reveals that students had a positive learning experience, as is evident from results of questions Q2 (Only 19% said that the worksheets were not engaging), Q3 (only 25% said they did not enjoy the worksheets) and Q7 (only 10% said that this method did not improve their learning). The biggest challenge for students was to work collaboratively with their peer, as is evident from results of the outlier question Q9. Evidently, more work needs to be done in this area. It may seem that the course content is not adequately covered since the teaching time is reduced, but response from question Q10 shows that less than 5% students felt that the class time was not used in a goodway. Overall, the results of this study were found to be very promising and optimistic towards effectiveness of the proposed pseudo-flipped method in teaching large programming classes.

FUTURE WORK

This is an ongoing research. Further research needs to be done to see the impact of the proposed method on course grades. It will also be interesting to apply data mining to reveal association rules (AR) between some of the positive and negative responses (An example of AR is: "I enjoyed the class" -> "I found the worksheets helpful in learning the material" with 60% confidence) .

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