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Research Article

Flipped classroom style and use of AI: the example of calculus course

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Abstract

The flipped classroom is an active and interactive education method that helps instructors to promote a significant change in the teaching and learning process, inverting activities, and transform the traditional teaching and learning styles. The application of the flipped classroom style is not simple and involves the instructor's commitment and consistency to facilitate the student self-regulation of activities to promote learning, especially in such difficult subjects as mathematics, physics, chemistry, etc. However, with the nowadays development of the Artificial Intelligent (AI), a lot of possibilities to engage students into the learning process arise. The objective proposed in the current work is to discuss positive and negative aspects of the flipped modulus style and use of the AI in the flipped style method on the example of the first year Calculus course. To assess the results varied methodologies have been applied. We use cross-institutional qualitative and quantitative analysis, as well as discourse analysis to achieve our goals. The results were satisfactory. It appears that in average the student's scores in the Flipped Classroom environment are by 5% higher than the ones in the traditional classroom. Moreover, for some of the topics, the different is 14.5% in favour of the Flipped Classroom style.

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Introduction

The flipped classroom teaching model has received a lot of attention in recent years. The main goal of a flipped classroom is to enhance student learning and achievement by reversing the traditional model of a classroom, focusing class time on student understanding rather than on lecture. To accomplish this, teachers post short video lectures online for students to view at home prior to the next class session. This allows class time to be devoted to expanding on and mastering the material through collaborative learning exercises, projects, and discussions. Essentially, the homework that is typically done at home is done in the classroom, while the lectures that are usually done in the classroom are viewed at home. There are numerous potential advantages to this style of learning. However, there has been some criticism to this bold new model of teaching and learning. We direct the reader to the following papers and the references therein: (Berrett, 2012; Khan, 2011; Smith, 2012).

The outbreak of the COVID-19 pandemic which led to the closing of colleges and universities has had a significant impact on student's education. The current community need is to adopt the traditional college and university classroom to the new social and educational environment. One of the strategies is to use the flipped classroom mode see for example (Divjak et al., 2012; Linling & Abdullah, 2023).

Our goal in the current work is to study positive and negative aspects of the flipped classroom in the post-pandemic recovery and to propose ways to improve this teaching module.

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Method

Our study reports on student's perceptions of a 'Flipped Learning' experience, which was a cross institutional study, with first year business students studying calculus. Ethical approval was gained to survey students on their learning preferences and outcomes. We compare students in a traditional classroom environment to those in a flipped environment for the years 2022 and 2023.

Students with the 'Flipped Learning' experience had three stages to go through every class:

2020 *Mathematics Subject Classification.* 97B10, 97B40, 97B50.

- Pre-class Work: students watched videos, read book material and completed short quizzes.
- In-class Work: involved self-study, group works, games, applied problems and projects.
- Post-class Work: homework assignment or/and a small group project.

Students who followed the traditional classroom environment attended lectures in which theory was presented, followed by a practical homework assignment.

We present results from two surveys related to the study as well as a comparison of students responses on relevant examination questions. Students of both groups were invited to complete a 'learning experiences' survey. In addition to surveys, 10 examination questions were prepared to compare the learning outcomes of the two groups.

The "Learning Preference" survey was completed by 89 (58%) of traditional classroom students and 72 (68%) f flipped classroom students. See Table 1 and Table 2.

Table 1. Student opinions on learning preferences survey (I)

Student Opinions on Learning Preferences Survey															
Flipped Classroom (72 students)								Traditional Classroom (89 students)							
When I Study for Class															
When I Study for Class	←Not Very True ...Very True→							When I Study for Class	←Not Very True ...Very True→						
	1	2	3	4	5	6	Average		1	2	3	4	5	6	Average
I pull togrether information from different sourses such as lecture notes, videos, reading materials	0	7	14	18	24	22	0.33	I pull together information from different sources such as lecture notes, videos, reading materials	15	31	27	9	6	1	0.35
I was completing quizzes for pre-class work to make sure I understand the material I have been studying			4	9	21	38	0.53	I asked myself questions to make sure I understand the material I have been studying	39	26	18	3	3	0	0.44
I try to determine which concept I do not understand well	4	6	8	23	19	12	0.32	I try to determine which concept I do not understand well		2	22	42	19	4	0.47
Reading															
	←Not Very True ...Very True→								←Not Very True ...Very True→						
	1	2	3	4	5	6	Average		1	2	3	4	5	6	Average
I make up questions to help focus my reading	0	4	21	26	20	1	0.36	I make up questions to help focus my reading	47	32	7	3	2	0	0.53
When I become confused about something I go back to try to figure it out	0	2	25	23	14	8	0.35	When I become confused about something I go back to try to figure it out	0	3	10	38	28	10	0.43
Lectures															
	←Not Very True ...Very True→								←Not Very True ...Very True→						
	1	2	3	4	5	6	Average		1	2	3	4	5	6	Average
I would pefere having my lectures online so I can attempt them when it is best for me and as many times as I need	2	2	0	3	9	57	0.79	I would pefere having my lectures online so I can attempt them when it is best for me and as many times as I need	5	2	0	0	11	71	0.80
I have limited acess to technology	68	0	0	2	2	1	0.94								

Table 2. Student opinions on learning preferences survey (II)

Times of Learning															
	←Not Very True …Very True→							When I Study for Class	←Not Very True …Very True→						
	1	2	3	4	5	6	Average		1	2	3	4	5	6	Average
I prefer to learn new concepts and terminology from lecture	20	28	13	9	1	1	0.39	I prefer to learn new concepts and terminology from lecture either by myself	1	1	3	16	21	47	0.53
Answering questions in class and in-class activities helps me to apply new terminology and concepts	0	0	2	7	34	29	0.47	I wish we would have more in-class activities, it would help me to understand and apply new concepts and terminology better.	0	0	1	5	19	64	0.72
I learn new concepts and terminology more effective by doing lerning activities	0	0	2	6	31	33	0.46								
Workload															
	←Not Very True …Very True→								←Not Very True …Very True→						
	1	2	3	4	5	6	Average		1	2	3	4	5	6	Average
I am prepared to increase my workload to learn more effectively	24	33	11	4	0	0	0.46	I am prepared to increase my workload to learn more effectively	0	3	8	37	24	17	0.42
Completing learning activities before class adds to my workload	0	0	0	1	12	59	0.82								
Grades															
	←Not Very True …Very True→							When I Study for Class	←Not Very True …Very True→						
	1	2	3	4	5	6	Average		1	2	3	4	5	6	Average
Getting a good grade in this class is the most satisfying thing for me right now	2	10	12	22	17	9	0.31	Getting a good grade in this class is the most satisfying thing for me right now	0	6	11	31	29	12	0.35
The most important thing for me is to improve my overall grade: my main concern is getting a good grade	0	2	9	28	23	11	0.39	The most important thing for me is to improve my overall grade: my main concern is getting a good grade	0	0	1	3	48	37	0.54
I am getting frastrated when exam questions are appered to me not exactely the same as in assignments. I was expecting to be prepared for exams just by doing assignment questions	0	0	1	1	61	8	0.85								

Examination Question Comparison

Table 3. Examination question comparison

Question Topic	Flipped Classroom	Traditional Classroom
Vertex of parabola application	79.9	82.1
System of linear Equations	89.7	90.2
Differentiation: Chain Rule	94.3	87.1
Second derivative of function	97.1	82.4
Application of derivatives	96.3	83.5
Integration with substitution	82.6	79.9
Optimisation problems	81.8	78.7
Extrema of multivariable function	87.1	87
Lagrange multipliers	80.4	78.3
Area under the curve	81.1	79.4

Results

Positive Aspects of Flipped Classroom

Based on our statistics, there are lots of *positive* aspects of flipped Classroom used during the post-pandemic recovery, among them are:

Students had more control over their own learning

By providing short video lectures at home and short pre-class quizzes, students had the freedom to learn at their own pace. Students could pause or rewind the lectures, write down questions they had, and discuss them later in the class. This allowed students to take their time reviewing the material (if they needed more time to understand certain concepts) without being left behind. As a result, this improved student achievement, as well as their behavior in class.

Lecture accessibility

Having video lectures and assignments online, students forced to miss class due to illness, sports, vacations or emergencies, could catch up quickly. Also, 24/7 access to the class material allowed parents to be better prepared when attempting to help their children and gave them insight into the quality of instruction given the students.

It motivates students to collaborate

With flipped classroom the in-class time is used to master skills through collaborative projects, discussions, games, competitions. These not only encouraged students to teach and learn concepts from each other, but made them work as a team member, which is very important skill in our daily life. By allowing students to assist in their own learning, they were able to own and share the knowledge they achieve, which in turn builds confidence. On the other hand, teachers could more easily identify errors in student's thinking or applications of concepts, and are more available through one-to-one interaction.

Negative Aspects of Flipped Classroom

Despite the many positive aspects of flipped learning there were *negative* aspects as well:

It can create a digital divide

It is the necessary for students to have access to a computer and the Internet in order to view the lectures. This is particularly hard on students from low-income districts who already have limited access to such resources.

It relies on preparation and trust

Flipped classrooms are dependent on student participation. We must trust students to watch the lectures and do quizzes at home. Unfortunately, there is no way to guarantee students will oblige or cooperate with the flipped model. There is significant work required for pre-class activities The flipped learning puts an extra workload on students. Even though it was suggested students spend no more than one hour for the pre-work, some students might be spending way more time on it due to personal problems, luck of understanding of the particular material, etc.

Not naturally a test-prep form of learning

Flipped classrooms do not "teach for the test"—it does not follow the model of teaching to improve standardized test scores. However, students are still required to spend a much time preparing for state-mandated testing, which in turn interrupts the flipped classroom process. While students expecting the test questions be exactly the same as assignment questions, the Flipped Classroom Model assures creative thinking over memorisation.

Conclusion

Despite some issues, the flipped classroom is still a very effective, hands-on approach to improving student achievement and involving them in their own education, especially during the post-pandemic recovery. To improve Flipped Classroom Techniques we suggest that the College/University has to insure that students with limited computer access have a place in the computer classroom to work there. The pre-class work should be followed by a short, scored quiz—it will motivate students to prepare for the class better and it will give a teacher idea how class is prepared. Ideally, the artificial intelligence (AI) should be used for grading and generating different variants of the post-class quizzes to show immediate score to the student. Based on the outcome, when students see score right after submission of their work, they are more motivated to reflect and attempt their quiz more times. In regards of the video-lectures have to be short and dense and the pre-class quizzes should not be long. We are testing only if students understand the concepts—not the whole topic. It is recommended to use AI to turn also

voice to text.

The productive in-class time will bring students better understanding of the applications of the topic. Instructor should explain to students (from day one) that they are taking this class not to pass it but to develop their logic and creative thinking. Students must know that the questions provided for assignments are not the same questions they will get in the tests, so they should study core of the concepts instead of memorising steps of each particular problem The in-class concept should be delivered in an interactive way. It is recommended to use different AI chatbots and visual design tools for the in-class activities such as group works, discussion, games, etc.

The post-class assignments would have to reflect the in-class concepts. Students have to be motivated by in-class activities to complete their post-class work. One can use students' chats to allow students to discuss hard problems in the assignment. To perform better visualization and computation in mathematics some of the studying topics might allow to use help of such AI platforms as: Wolfram alpha, Socratic, Copyscape, Tutor.ai, Gradescop, Zotero, to name a few.

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