Customizing Course Redesign and Flipped Classroom Models to Improve Learning Environment

Taeil Yi and Jerzy Mogilski

***Abstract*—**This article is about a successful adoption of course redesign model of mathematics courses at the Department of Mathematics in the University of Texas at Brownsville (UTB), a Hispanic serve university in the south Texas. Around 2007 National Center for Academic Transformation (NCAT) recommended six models for using of information technology to redesign courses in mathematics: the supplemental model, the replacement model, the emporium model, the fully online model, the buffet model, and the linked workshop model. Because of the local educational environment and resources none of the six models could be implemented exactly like it was described by NCAT. It was required to modify a model or combine several models together to provide to our students more supplementary materials through online and not reduce contact hours. This approach had a lot of common with the 'flipped classroom'. The Department of Mathematics in the UTB has worked on a series of course redesign projects from developmental mathematics course to graduate courses in MS degree program mainly with this model for last 8 years. The authors discuss how the specific model has been developed and adopted, what course contents are developed, and the impact of course redesign on students' success and their study habits. The grade comparison between traditional in-class courses and re-designed courses, and some suggestions for those who want to do their own course redesign in a similar situation are also presented.

***Keywords*—**Course redesign, flipped classroom, online course, standards for online course content.

I. Introduction

TECHNOLOGY related to teaching/learning plays a vital role in 21st century education [2], [10], [19], [20]. It helps to reduce many obstacles in delivering lectures and learning environment such as distance, cost, delivering hands-on activities, tutoring, and customized study modules. Through educational technology we can provide live teaching to remote areas, and at the same time decrease expenses by re-sizing the number of students in a class.

For last 8 years the department of mathematics in the University of Texas at Brownsville (UTB) has been extensively involved in course redesign. We secured several grants from the Texas Higher Education Coordinating Board (THECB) for redesigning developmental mathematics courses and undergraduate courses in elementary statistics and calculus 1. The THECB's 1-year course redesigning pilot project, which was called *fast track* project supported the redesigning of Calculus 1 course. It was a collaborated work among three University of Texas schools (UTB, UT-Tyler and UT-Permian Basin). The other two undergraduate courses were redesigned through the THECB's 2-year course redesigning projects (called *regular tracks*).

Encouraged with these first experiences in course redesign the department decided to work on courses in college algebra, pre-calculus and Mathematics for liberal arts. It was done without external funds by a group of enthusiastic faculty in very short period of time.

There was also very significant work done on the graduate level courses. Since 2010 using funding from the PPOHA grant from the Department of Education (DoE) of US government we have produced online contents for thirteen graduate mathematics courses, especially for in-service high school mathematics teachers in the 'teaching track' of MS in mathematics degree program. This course development had a vital role to initiate the Online MS in mathematics degree program in UTB, which was approved by the THECB.

II. Technological Infrastructure in UTB

In 2003 the UTB implemented a Learning Management System (LMS) called Blackboard Course Management System for faculty to provide online platform for course delivery. The UTB acquired a campus-wide Blackboard Enterprise License and made it available to all faculty members by creating a 'course shell' for every class section as well as providing a community portal for faculty and students. It also implemented Horizon Wimba Live classroom and Voice Tools. This synchronous and asynchronous tool allows faculty to chat via voice and text with students. It was later upgraded to Collaborate which has video and screen sharing features. Faculty and students are also able to create and send voice announcements, voice emails and post voice messages in the Blackboard discussion boards. A campus-wide wireless network is available as an alternative to the regular wired network. The redesigned course contents are uploaded to the live course in the Blackboard, and delivered to the students. In 2007 the mathematics department received a grant from the

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Department of Defense (DoD) of US government to establish classrooms equipped with laptop computers. The redesigned undergraduate courses have been delivered in these computer-equipped classrooms.

III. Searching for Course Redesign Model

When we started to work on the course redesign project it was suggested to consider models for course redesign developed and recommended by National Center for Academic Transformation (NCAT, http://www.thencat.org/) [22]. For number of years NCAT led experiments on many university and college campuses with ideas which now could be considered similar to flipped classroom concept.

At the time when the course redesign projects were being started in the UTB there were six models that emerged from NCAT's program for using information technology to redesign courses in mathematics: the supplemental model (that retains the basic structure of the traditional course and supplements lectures and textbooks with technology-based, out-of-class activities), the replacement model (that reduces the number of in-class meetings and replaces some of them with out-of-class, online, interactive learning activities), the emporium model (that replaces lectures with a learning resource center model featuring interactive computer software and on-demand personalized assistance), the fully online model (that eliminates all in-class meetings and moves all learning experiences online), the buffet model (that customizes the learning environment for each student), the linked workshop model (that provides remedial/developmental instruction by linking workshops).

The team of mathematics faculties in the UTB analyzed each of the models carefully especially from the point of view of the students' population that we were dealing with in our region, the Texas Rio Grande Valley (RGV). The UTB is located at the southernmost tip of the state along the Mexico border and the Gulf of Mexico. According to the 2010 U.S. census, the RGV is the fastest-growing area in the U.S. with a population of almost 1.2 million, the largest percentage-Hispanic population (90.5%) and the lowest average income per year ($27,244). The RGV region has an average poverty rate of 33.8%, with one third of the population living in poverty compared to the State of Texas average of 12.9% and the national average of 9.9%. Most of the students in this area are no traditional full time students, rather a part time students working more 40 hours per week supporting themselves and their families. In many cases they were not really ready for college and they did not have study habits to be successful in a redesign model which does not forces them to attend scheduled classes. The UTB were dealing with other constraints and limitations like lack of funds and lack of big classrooms on the campus. The department of mathematics wanted to provide to our students more supplementary material (through online), and yet not to reduce contact hours. Because of this goal and the given environment we could not implement any of the six models exactly like it was described by NCAT. The supplemental, replacement and fully online models did not work for us. We did not have resources for the buffet and linked workshop models. However the emporium model had several features that we wanted to use. Unfortunately, the lack of space did not allow us to implement it. Instead we decided to work on customized version of the emporium model.

In our model we kept the same number of contact hours but we designed the classroom activities differently we organized courses in big sections of 60-75 students. Briefly, our model consisted of lecture material online, mini-lectures in classroom (discussion of the online lecture material), interactive lab activities (in computer lab), written homework, online homework, quizzes, and proctored tests. The interactive labs were conducted by instructors with a help of tutors. In addition, the model included open tutoring center for walk-in tutoring.

When we were working on improvement of our course redesign we learned about a new form of blended learning called *flipped classroom.* It was a "pedagogical model in which the typical lecture and homework elements of a course are reversed. Short video lectures are viewed by students at home before the class session, while in-class time is devoted to exercises, projects, or discussions [20]." Flipped classroom had a lot of common with our model and we used it for further improvement of our course redesign.

IV. Customizing Emporium model

Most of the classrooms on the UTB campus are of midsize. For this reason the lower level courses were taught traditionally in sections consisting of around 30 students. Just the college algebra courses consisted of more than 40 sections per semester to accommodate all students. It required a lot of lecturers and adjunct faculties to cover the courses. The courses were not coordinated. Each of the instructors taught his or her courses giving grades according to different standards.

Table. 1 Faculty assignment for course

<table>
<tr><td rowspan="2">Traditional (TL)</td><td>Course 1 Section 1</td><td>Course 1 Section 2</td><td>…</td><td>Course 1 Section N</td></tr>
<tr><td>faculty</td><td>faculty</td><td>…</td><td>Faculty</td></tr>
<tr><td rowspan="3">Redesigned (RD)</td><td colspan="4">Course 1 (coordinated by the instructor of record)</td></tr>
<tr><td>Section 1</td><td>Section 2</td><td>…</td><td>Section N</td></tr>
<tr><td>Adjunct faculty/ TA</td><td>Adjunct faculty/ TA</td><td>…</td><td>Adjunct faculty/ TA</td></tr>
</table>

Through the initial redesign we reduced the number of sections by half. For instance the college algebra had only 20 sections of 75 students accommodating more students than before. The classroom meetings were schedule according to the regular university schedule (3 contact hours for 3 SCH courses and 4 contact hours for 4 SCH courses per week). The contact hours were equally divided between two activities mini-lecture and interactive lab. We used only two big classrooms for teaching the courses and the course sections were alternating between the rooms. One classroom was for mini-lectures that were devoted for discussion of the online lecture material and for presenting examples. For this activity the students were meeting only with the instructor who was assigned to the section. The other classroom was for the interactive lab activities. Initially, the room was equipped with laptops that we purchased through the project 'Mobile Mathematics

Laboratory' funded by a DoD grant. Later we moved to a desktop computer lab. Each lab was stuffed with an instructor of the course and 2-3 undergraduate or graduate students who worked as tutors. The student were assigned 5-10 problems on their computers and while working on the problems they could use help from instructors, tutors and their peers. Having computers in the front of them the students could use any resources available for the course but they were required to submit their solutions by the end of the lab meeting. The lab work was graded and it was a small part of the final course grade. The remaining course activities like homework and quizzes were 100 % online but students could seek help going to our open tutoring center.

All sections of each course were coordinated by one faculty member who was in charge of the course syllabus including the course calendar, timing of various course assignments, method of grading and student assessments. Our course redesign was cost effective to this extend that we generated enough funds to cover the cost of coordination, to pay tutors and to maintain open tutoring center for additional help for students in the courses. The redesigned courses served each semester around 1,500 in college algebra, 600 in mathematics for liberal arts, 200 in statistics, 200 in pre-calculus, 120 in calculus I and in addition 1,200 in developmental mathematics courses. Since we used only two classrooms the other courses could be scheduled in vacated classrooms. In the next section we show an example (calculus 1 course) of the course contents we have developed to present how they are delivered and used.

V. Course Redesign Content

The fast track project for Calculus 1 was supposed be done in one year by three mathematics faculties (one from each university), and there was no time for preparing course contents. So the main goal of the fast track project was utilizing pre-existing sources for the online content. The THECB suggested the National Repository of Online Courses (NROC) Project [22], and the lesson files (html including lecture videos) for Calculus 1 was provided for us from the NROC. After the first pilot year we (UTB) decided to produce our own course content for Calculus 1 course, including question pools. The main reasons for this decision were 1) there are some missing content in NROC source, 2) there are many mistakes in the content and questions, and 3) we had to contact the NROC to request the fixed/modified content and it takes time to fix it.

For the other four undergraduate courses we decided to use the materials, i.e., contents, question pools, and lecture videos from the textbook company, which are mainly PowerPoint files with audio from textbook contents so it covers all the necessary materials and have only a few mistakes. Since producing course contents for even a single course requires too much time and cost, we did not want to produce our own course contents for these four courses.

Through the modified flipped classroom model we have designed, including 'Open Tutoring Center', we offer these five courses. As an example, we show calculus 1 course contents and how they are arranged and used. The traditional in-class lecture course setting (TL) for Calculus 1 in UTB was 3 lecture hours and 2 lab hours for 4 student credit hours (SCH), and one faculty was assigned to each section of maximum 30 students. The re-designed flipped classroom setting (RD) requires 3 classroom meeting hours for the same 4 SCH, and one faculty is assigned as the instructor of record for the entire calculus 1 course. Each section (max 70) is assigned to 1 or 2 classroom instructor(s) who are lecturers or graduate teaching assistants. Each session consists of two activities: pre-classroom activity and in-classroom activity.

Table. 2 Example schedule for calculus 1 course

TL	Mon	Tue	Wed	Thur	Fri
9:00-9:50	Sec 1 Lecture	Sec 1 Lab	Sec 1 Lecture	Sec 1 Lab	Sec 1 Lab
10:00-10:50	Sec 2 Lecture	Sec 2 Lab	Sec 2 Lecture	Sec 2 Lab	Sec 2 Lab
RD	Mon	Tue	Wed	Thur	Fri
9:00-10:15	Sec 1 Class meeting	Sec 2 Class meeting	Sec 1 Class meeting	Sec 2 Class meeting	

Before each in-classroom meeting students are required to 1) read the assigned lecture note, 2) watch the corresponding lecture video(s) and 3) attempt online 'Home quiz' (multiple choice) up to 3 times. The in-classroom meeting is used for discussion and a 'Lesson test' which is an online quiz given to student at the end of each classroom meeting.

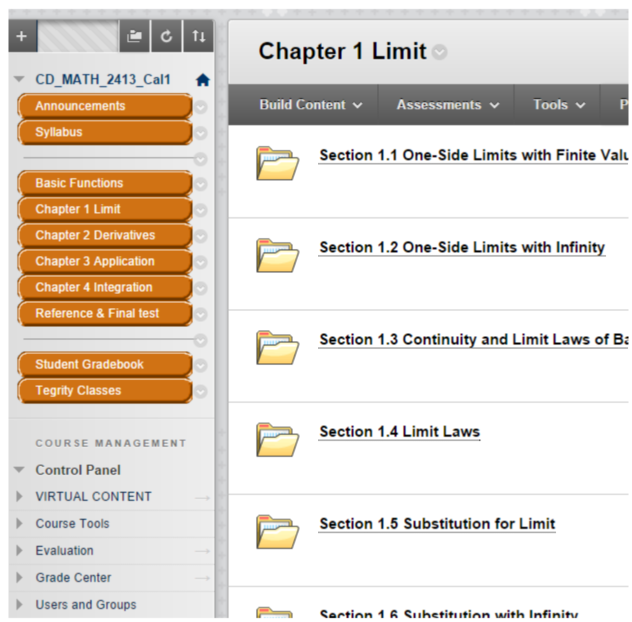


Fig. 1 calculus 1 – chapter 1 in blackboad

The department of mathematics also offers Open Tutoring Center in a reserved workroom for all students taking these 5 courses. Faculties and graduate teaching assistants are assigned as tutors to the center, so students can get help from one or two tutors whenever they come to the center during the center's operating time (from 9:00am to 5:00pm from Monday to Friday).

After the pilot year we have produced lecture note (pdf), lecture videos by Jing and Smartpen, graphs and hands on applets by GeoGebra, and more than 500 question pools using

Wimba Diploma software. Each question pool contains between 10 and 40 similar questions. The online contents in the course Blackboard are:

- Announcement
- Syllabus
- 5 chapters (40 lessons) including 'Basic Functions' as a preliminary
- 4 Unit tests (password protected)
- Final (password protected)

Each lesson consists of lecture note(s), lecture video(s), hands-on applets, examples, Home quiz (up to 3 times), and Lesson Test (1 time, password protected).

VI. TRADITIONAL (TL) VS. REDESIGNED (RD)

The flipped classroom has been known as a more effective model to help students learn than the traditional class structure [3], [4], [9], [12], and we can witness several evidences such as: an average increase of 21% on exam questions in introductory biology at University of California at Irvine, showing strong self-ratings of students' abilities in a software engineering course at Miami University (Ohio), and showing a significantly higher success rate on the exam problem in linear algebra course at Franklin College (Indiana) [8]. Our study with our own model shows somewhat different. The passing rates (letter grade of A, B or C) in Elementary Statistics and Developmental Math courses are increased, i.e. 52.7% to 63.3% in Elementary Statistics course and 49.5% to 50.9% in Developmental Math courses (Table 4, 6 and 7). The passing rates in Calculus 1, College Algebra and Math for Liberal Arts are decreased, i.e. 52.8% to 41.9% in Calculus 1 course, 46.3% to 38.2% in College Algebra course, and 68.5% to 45.8% in Math for Liberal Arts course (Table 3, 5 and 8). The overall passing rate among these 5 courses decreased 8.4% from 52.9% to 44.5%. It could be partially explained by complete course coordination which eliminated grade inflation.

Some study show that students' perceptions of the flipped classroom are somewhat mixed, even are generally positive overall [6]. Our study shows the similar results for the first couple of years. The major complain during the semester was 'mistakes in quizzes and tests'. We haven't got that much complains after we produced our own content materials, even there were still some mistakes. We will discuss other students' response in the next section.

Hasan describes that students could not perform any of the typical tasks successfully on some selected websites [8]. We had the similar situation in somewhat different reason. Since the online quiz result is counted in a portion of student's course grade, 3 attempts on the quiz encourages students do pre-study of the content before the in-class meeting. At least that was our intention, but it turns out that many students just did the quiz 3 times without studying and came to the in-class meeting, since we used the same question pools for each quiz. When a student retakes a quiz, the numbers in the quiz are changed randomly. But the question wordings are exactly same, so many cases students can guess what the right answer is after a couple of trials. When they don't get enough information during the in-class meeting, they get a bad scores on the lecture test, which is given only one time at the end of each in-classroom meeting.

The comparison of course grades assigned to students between TL and RD are illustrated below (Table. 3 ~ Table. 8).

Table. 3 Math2413 – Calculus 1

	A	B	C	D	F	W	Total
05S	13	11	15	8	15	21	89
05F	5	8	19	6	14	27	95
06S	12	8	14	2	8	21	97
06F	7	19	26	3	16	19	108
07S	15	20	19	7	9	12	148
07F	1	10	12	7	30	24	152
08S	23	14	15	7	13	26	119
08F	7	18	16	18	18	18	117

A	B	C	D	F	W
13.0%	16.5%	23.3%	6.5%	15.5%	25.1%
11.2%	15.2%	15.5%	11.6%	22.0%	24.5%

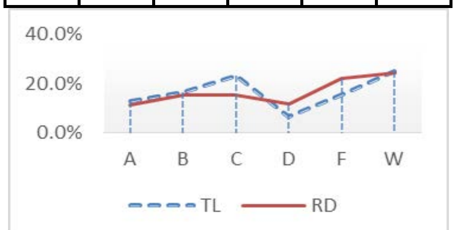


Table. 4 Math1342 – Elementary Statistics

	A	B	C	D	F	W	Total
05S	14	20	21	4	15	15	89
05F	12	23	28	7	15	10	95
06S	11	22	23	8	17	16	97
06F	14	7	14	10	15	48	108
07S	22	35	17	21	20	33	148
07F	22	41	45	21	14	9	152
08S	13	36	22	12	26	10	119
08F	7	31	29	21	21	8	117

A	B	C	D	F	W
13.6%	19.9%	19.2%	9.3%	15.3%	22.7%
10.8%	27.8%	24.7%	13.9%	15.7%	7.0%

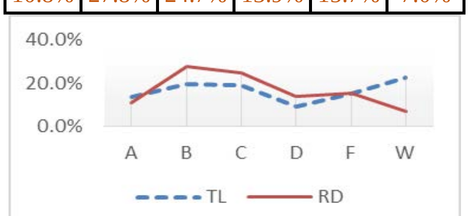


Table. 5 Math1314 – College Algebra

	A	B	C	D	F	W	Total
05S	55	111	142	76	194	193	771
05F	106	165	210	107	156	153	897
06S	72	122	126	95	195	185	795
06F	155	157	189	92	146	229	968
07S	66	129	125	82	157	187	746
07F	37	115	129	124	267	137	809
08S	33	73	107	67	210	95	585
08F	57	133	184	141	221	138	874
09S	46	96	122	115	217	103	699

A	B	C	D	F	W
10.9%	16.4%	19.0%	10.8%	20.3%	22.7%
5.8%	14.1%	18.3%	15.1%	30.8%	15.9%

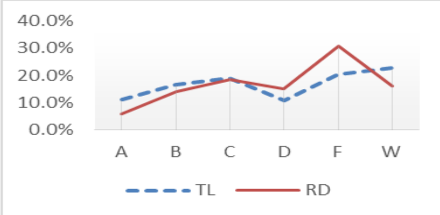


Table. 6 Math0421 – Developmental Math

	A	B	C	D	F	W	Total
05S	27	44	43	31	103	33	281
05F	18	57	68	41	90	35	309
06S	19	42	36	42	51	22	212
06F	19	59	95	29	53	32	287
07S	17	36	53	31	56	39	232
07F	19	35	67	40	80	17	258
08S	15	25	64	34	76	37	251
08F	7	31	84	42	76	33	273
09S	12	55	78	26	78	33	282
09F	18	77	105	35	77	28	340

A	B	C	D	F	W
7.3%	16.3%	23.3%	13.6%	27.8%	11.7%
4.1%	18.2%	29.8%	11.5%	25.8%	10.5%

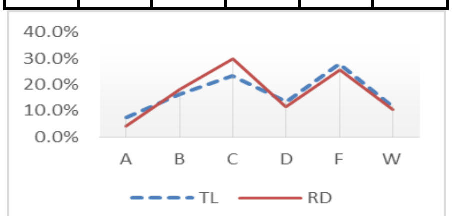


Table. 7 Math0422 – Developmental Math

	A	B	C	D	F	W	Total
05S	37	82	77	53	82	43	374
05F	18	53	85	73	94	36	359
06S	22	51	96	48	81	42	340
06F	21	65	101	50	56	35	328
07S	16	43	93	46	61	46	305
07F	24	58	89	56	68	32	327
08S	17	67	84	31	41	32	272
08F	14	72	97	35	36	24	278
09S	7	38	49	51	107	21	273
09F	11	59	98	57	78	44	347

A	B	C	D	F	W
6.7%	18.2%	27.1%	15.5%	21.0%	11.5%
3.6%	18.8%	27.2%	15.9%	24.6%	9.9%

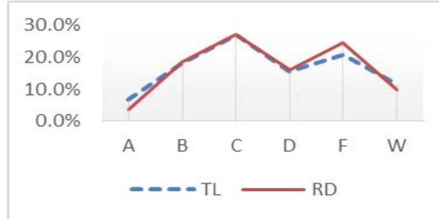
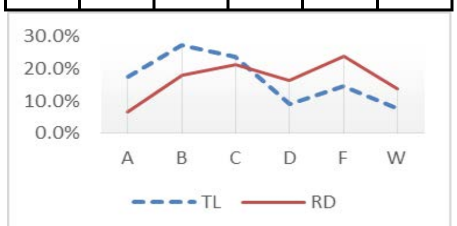


Table. 8 Math1332 – Math for Liberal Arts

	A	B	C	D	F	W	Total
05S	68	112	98	24	53	39	394
05F	81	127	83	32	58	24	405
06S	59	110	87	34	70	26	386
06F	56	126	92	25	45	31	375
07S	68	73	93	46	58	38	376
07F	62	96	90	40	51	22	361
08S	69	75	84	33	54	27	342
08F	24	66	67	73	98	50	378
09S	22	63	86	45	74	48	338

A	B	C	D	F	W
17.5%	27.2%	23.8%	8.9%	14.7%	7.8%
6.4%	18.0%	21.4%	16.5%	24.0%	13.7%



VII. Discussion

The three major students' complains in their course evaluation at the end of each semester are:

1) "There was no lecture. I don't like online course."
2) "The online lesson is not enough and I want to see more examples."
3) "I had to study!"

Even we provided lecture videos in the course Blackboard, many students didn't watch the online lecture videos, and they expected traditional lectures by their instructors during in-class meetings, especially in the first several semesters when the new model introduced. For some students who wanted to study more the 'fully explained' online examples were not enough, and wanted more. One of the reasons for this type of complain is that the instructor always asked students if they have any question regarding the assigned contents, and gave the explanation first if students ask any. In most cases those questions from students are about the online examples and questions, which have the solution and the explanation in the online content already. So this situation makes the student who finished the online content before the in-class meeting feel redundant and boring, and demand more explained exercise questions to study by themselves. Frankly we were delighted whenever we got the response like in 3).

A. Advantage vs. Disadvantage

As described above many students didn't study online contents and just came to the in-class meeting while expecting that they would get enough explanation about the course content. When they find that the instructor covers other students' questions in the first place and spend most of the meeting time, they feel that they are abundant and the instructor is not giving lectures they expected, or at least the instructor's explanation is not enough. Another main disadvantage of the re-designed model (especially for Calculus 1 course) was that we have limited access on students' performance on calculation. Since students are required to do pre-study with the online course contents, we couldn't give more assignment to check how they come up to the solution. The chapter tests and the final test also consist of multiple choice questions only, so we couldn't check their actual calculation skills.

On the other hand, we found that following benefits through the re-designed course setting:

1) In the traditional setting there were serious non-consistency on the course content coverage on different sections, actually among the instructors. It had caused serious problems when students from different sections of the previous course take consequence course. In many cases the instructor of the consequence course had to re-teach some parts of the previous course. It forced the instructor to speed up the instruction to cover the remaining course content, and found out that there is not enough time to cover the assigned course content. Under the re-designed model, the entire course content are uploaded and scheduled for the entire semester ahead. There is only one instructor of record for each course (all 5 of them are multi-section courses), who guides the classroom instructors for all sections of the course. Hence all sections in each course covers the exact same course contents.

2) Another problem in the traditional setting was non-consistency on students' assessment among sections, or more likely among instructors. On an extreme case one instructor in developmental mathematics course gave the letter grade 'A' to every students in the sections the instructor taught for several semesters, while the other instructors' course grades are distributed among all letter grades (A-F). Through the communication with students we found out that students showed preference on certain instructor(s) for that reason in many cases. Under the re-designed model we used pre-uploaded quizzes and departmental tests. There is no grade inflation and we can maintain the consistent assessment of students' achievement for the entire course. We believe that this is one of reasons for the declination of course's passing rate when the re-designed model was adopted.

3) The re-designed model changes students' learning behavior. The office hour in the traditional setting was not popular, and only a few students came during the instructor's office hour which was 5 hours per week for each instructor. The open tutoring center (9am to 5pm, Monday through Friday) offered for the re-designed model courses was always packed with students, and became most interactive place among students. Students can get help from assigned tutors and/or from other students while they are visiting the center without time restriction through the week days. We have witnessed that students are helping each other even among the ones in different courses. It really helps to increase students' self-study skills.

4) The new model helps decreasing teaching cost for students and school both. For example, the lecture note (replacing textbook) was produced for calculus 1, so students are not required to buy textbook. Since the re-designed model requires one record of instructor for a course, and the classroom meeting for each section was guided (under the guidance of the record of instructor) by lecturers, adjunct faculties and graduate teaching assistants, the teaching cost for a course with 10 section for example has been reduced to about $27,500 with the re-designed model from about $75,000 with the traditional setting. Another unexpected benefit from the re-designed model is that several graduate students are supported financially.

B. Findings and Suggestions for flipped classroom model

Through the experience from the re-designed model we found several interesting students' behaviors in studying.

There are two kinds of extreme cases of students: one who attend the classroom meeting without pre-studying, and one who want everything in their hands, especially the hard copy of lecture note. Students in the first case didn't read the textbook or lecture note and never watch the lecture videos before the class meeting. They expect the classroom meeting or the classroom instructor would provide the necessary information about the course material. The new format of the re-designed model should be explained several times in the beginning of the semester, and the detailed guidance should be provided through the semester. We believe that the students' demand in the second group is because of their study habits from the traditional model. To support their studying habit it is necessary to provide at least one type of 'printable' format of files, such as pdf.

The uploaded course contents are the only resources that students can use for study. Students do not study more than assigned examples and self-exercise questions unless the instructor assign something else. The online contents should provide more than 'necessary' study materials.

Until students become familiar with the re-designed model most of them would be confused about the course assignment and what part they should do. Pre-study by themselves before the class meeting will be very difficult for those who do not have well-developed self-study habit. That is why the 'step-by-step' and/or itemized daily course instruction is critical for the success of the re-designed model teaching, and well-planed (daily, if possible) course guide should be provided to students.

Since the majority of the course content should be done by students, even a single mistake in the content, especially online quiz/test question will cause a big trouble for students, and make students frustrated and discourage them eventually. We strongly suggest that the produced course contents should be rechecked several times by many people (if possible) before uploaded.

The online content can be used for emergency cases such as non-prescheduled campus close-down because of bad weather. It is recommended to upload 'every' course content, including the part which will be covered by the classroom instructor during the classroom meeting. The course syllabus should include what students need to do in such events.

In many occasions we have received student's requests of extending the due date of required work. Most of such requests were claimed because of technical problems of student's side such as bad internet connection, virus on their computer, etc. There is no method to check these types of claims, and hence such request should not be accepted and clearly mentioned in the course syllabus. We also recommend to give several chances for the part assigned to students, i.e., the 3 possible attempts for home quiz in calculus 1 course.

C. Standards for course content for flipped classroom

We have come up some suggestions and our own standards for flipped classroom model from our experiences.

1) Suggestion for Course Content Production:

The 'printable' lecture note should be provided unless a textbook is introduced. This is necessary for students who want hard copy for their study. For better explanations dynamic graphs and/or hands-on applets should be produced and uploaded. The html is the best file format for dynamic graphs and applets, and we recommend GeoGebra which is a free open source dynamic graph computer program to produce graphs and applets within html formats. Fully explained examples and at least three 'self-explained' exercise questions per each example should be provided. Lecture videos for the content and examples are the main part of online content. For producing lecture videos of mathematical definitions and theorems Beamer (a presentation file produced with LaTex) files are recommended, and a screen capture program such as Jing or SnagIt is recommended to capture the monitor activity with voice. To show mathematical calculations the 'Smartpen' can be very useful to produce animated pdf files including free hand-writing with audio. Enough number of question pools for online quiz/test are another main part of online content. At least 4 different midterm and final test sets are necessary to cover 4 semester span.

2) Suggestion for Course Delivery:

A very detailed check list for weekly (even daily, if possible) course schedule should be provided for guiding students. This check list can be place in the course syllabus, or given inside a weekly module. The use of specific dates in each semester is recommended instead of generic schedule terms like 'week 1', 'week 2', or 'day 1' and 'day 2', etc. To encourage students weekly (even daily, if possible) reminder e-mail is necessary. For online office hour a live communication method should be provided such as Skype, Elluminate or Collaborate. A touch screen computer is very useful for this kind of online office hour interaction with students. Sometimes the 'Smartpen' record is better to provide explanation of calculation, which can be sent as an attachment file through e-mail. The instructor should respond student's e-mail within 24 hours.

3) Standards for Online Course Content:

From our study we have derived the following standard for online course content for flipped classroom setting, and is suggested whenever a new course is produced or redesigned with the flipped classroom format.

- Detailed daily course schedule
- Textbook, or Lecture note in the format of PDF, PowerPoint, Beamer (for print out) and HTML (for including dynamic graphs and hands-on applets)
- Lecture videos for the lecture note content
- Enough number of fully explained examples including videos
- At least 3~4 exercise questions per example with feedback and the answer
- Weekly/monthly quiz/project
- Midterm and Final test

VIII. Conclusion

For last 8 years the department of mathematics in the UTB has re-designed 5 undergraduate courses and produced 13 graduate courses for the 'teaching track' in the online MS in mathematics degree. A customized emporium model, one of six models recommended by NCAT, was chosen for new teaching model for those 5 undergraduate courses because of local educational environment and resources, which turned out later having a lot of common with the flipped classroom model. The authors found interesting outcomes through the experience. The purpose of this study is to share our experience and findings in several course redesign projects which converted several mathematics courses to flipped classroom setting from traditional in-classroom lecture setting. The author wish the study could help anyone considers a course redesign including online course content. One 'fast track' and four 'regular track' projects partially supported by THECB were the main driving force for our study.

Based on the outcome of our study, it is concluded that:

1) Course passing rate would be dropped most likely for the first several semesters when the newly designed course setting is implemented, mainly because a) the course contents are not enough, b) they are not 'clean' enough (saying many mistakes), and c) students are with the old study habit and not familiar with the new model.

2) The convert from the traditional setting to the flipped classroom model requires time and cost in the first place, but eventually will save the teaching cost which may vary depending on the setting.

3) The online contents need to be modified in regular base. The flipped classroom model doesn't reduce instructor's effort and time devoted to preparing and teaching a course. It helps to reduce the lecture time for face-to-face instruction. It increase students' self-study time.

4) Without a guidance for weekly (or daily if possible) activity for students, students feel that there is no instruction for the course. Detailed daily schedule for students' study should be provided. The regular course syllabus is not enough for flipped classroom modeled course.

5) Several workshops are necessary for faculty who are going to teach the flipped classroom modeled course as the instructor of record or the classroom instructor, especially if they are not involved in the course content production. At least one of the workshops should cover how to operate live interaction program and how to produce lecture video with 'Smartpen'.

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