From MOOC to SPOC: Fable-based Learning

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Abstract. This presentation gives the pedagogical innovations and experience of the co-development of three MOOCs on the subject of "Modeling and Solving Discrete Optimization Problems" by The Chinese University of Hong Kong and the University of Melbourne. In a nutshell, the MOOCs feature the Fable-based Learning approach, which is a form of problem-based learning encapsulated in a coherent story plot. Each lecture video begins with an animation that tells a story based on a classic novel. The protagonists of the story encounter a problem requiring technical assistance from the two professors from modern time via a magical tablet granted to them by a fairy god. The new pedagogy aims at increasing learners' motivation and interests as well as situating the learners in a coherent learning context. In addition to scriptwriting, animation production and embedding the teaching materials in the story plot, another challenge of the project is the remote distance between the two institutions as well as the need to produce all teaching materials in both (Mandarin) Chinese and English to cater for different geographic learning needs. The MOOCs have been running recurrently on Coursera since 2017. We present learner statistics and feedback, and discuss our experience with and preliminary observations of adopting the online materials in a Flipped Classroom setting.

Keywords: Fable-based Learning · MOOC · Flipped Classroom

1 Preamble

This short piece of writing is intended to be a narrative of the work done between 2016 and 2020 on the use of Fable-based Learning in designing and teaching a series of Massive Online Open Courses (MOOCs) [3] on the topic of Discrete Optimization. The MOOC contents were later adopted to run as Small Private Online Courses (SPOCs) [6] in the classroom. It serves also as the basis of my Keynote Speech at the Fourteenth International Conference on Blended Learning, August, 2021. The following content is largely based on and revised from Lee [7] and Mavis *et. al.* [5].

This is also the story of how the East meets West, and how two very different cultures can synergize to develop novel pedagogies to design and deliver three highly acclaimed MOOCs on Coursera. While we shared our common research

interests, our work practice and value system are almost at the two ends of a spectrum. After the MOOCs were launched successfully in early 2017, they were later brought into the classroom in a Flipped Classroom setting. The whole thing began in 2015 when The Chinese University of Hong Kong (CUHK) was encouraging research collaboration with other universities.

With a good collaborator, Peter Stuckey, at the University of Melbourne (UniMelb), I applied for a research support from CUHK and spent a week at UniMelb. During that week, we had worked on mainly research of mutual interests. On the day before my departure, we had a casual chat over coffee and started talking about teaching our Discrete Optimization courses at the post-graduate level. Then we discussed about how we can promote our research area to the whole world. The answer was to do a MOOC. I thought I actually knew how to do it well because I had a bit experience in bringing story-telling and game-playing into a learning platform.

The idea is to design the MOOCs in such a way that learners would take the modules while watching a movie. Much to my surprise, Peter bought my crazy idea. Since Discrete Optimization is like magic, I immediately thought about the Harry Potter series of movies. After I returned to CUHK, I mentioned the possibility to our University's Pro Vice-Chancellors in charge of education, she found this a very interesting idea and gave me the full support but suggested that we based our MOOCs on a Chinese classic. Being a person of the West, Peter again bought into the idea. He also mentioned the potential collaboration to UniMelb's Pro Vice-Chancellor and received the same strong support. Then I started regretting since I knew I was getting myself into a tall tall task. It was 2015. The funding was approved after a few months and the project started in 2016. And the rest was history.

2 Massive Open Online Courses

Majoring in Mathematics and Artificial Intelligence, I always teach with many mathematical symbols, definitions, theorems and algorithms to illustrate concepts and methods. Many a times, students do not know why they would see a particular symbol, nor would they know why they would see a definition or theorem when professors teach them to solve problems. It is usually at the very end of a semester when students are told about the areas of application of what they have learned in the entire course.

I did some research and found MOOCs to usually consist of five elements. Basically, MOOCs are large scale public online courses, there should certainly be teaching videos in which teachers can raise interactive questions to gauge the understanding of the learners. Students could also be given reading materials for self-study. A forum should be provided for students to raise questions and for interaction among teachers and students. Some MOOCs would provide an auto-grading system. Others will let students mark assignments for one another.

While I was not certain, I went to the most popular MOOC platform, Coursera, to find out what a MOOC really is. I looked at MOOCs from various top

universities and teachers. Most teaching videos are basically slides augmented with voice and some with a small talking head. Of course, some productions are as professional as a TV show and some with animations to explain abstract concepts. After examining a few well-known MOOCs, I started asking myself of what exactly a MOOC is. What are the essentials for a good MOOC? Trying to be controversial, I would argue MOOC is nothing more than a one-way version of classroom teaching, one-way teaching from teacher to students. The teacher who gives lecture in the video would not be able to see the response of the students on the other side of the screen. Do not get me wrong. I believe in classroom teaching, which is the most ancient form of education delivery. In a classroom, however, the teacher can at least see if the students are interested, sleeping, or having any response. If the teacher senses that the students do not understand, the teacher can adjust the explanation and also teaching pace. MOOCs do not allow any of these classroom interactions since teachers cannot see the learners. Besides, learners watch the video asynchronously and at their own pace. Any interactions can take place only on the discussion forum.

My plan was to produce a MOOC that can overcome some barriers of one-way delivery issue. We want to produce a MOOC not because the quality of classroom teaching is not good. We fully support classroom teaching. Face to face teaching is very important. When MOOC teaching is only one-way, the problem of one-way teaching in classroom teaching will be exemplified. A weakness of classroom teaching, as I used myself as an example, is the teacher goes through a lot of mathematical theorems, students do not understand why they have to learn what is being taught. First, students learn without a proper context. In a classroom, they could at least ask the teachers but that is impossible in a MOOC setting. Second, when students get uninterested, they lose focus and will easily get distracted or even give up. I cannot emphasize enough the importance of maintaining students' interest and providing a clear context of learning. These are what we would like to address with Fable-based Learning.

3 Fable-based Learning

Many MOOCs face a serious problem. Usually we will see a high number of registrations of a course. Students will watch the first one or two lectures and then stop. The common reasons are that they do not have time, not interested or busy. They lost interest all of a sudden. It is of paramount importance for a MOOC to keep learners engaged. I want to produce a MOOC to change students learning experience.

The MOOCs are on the topic of Discrete Optimization which is a branch of AI, and are at the postgraduate level covering lots of mathematical concepts and computer programming. In order to attract students, we made and put a promotion video[1] for the MOOCs on YouTube. There are many different applications of Discrete Optimization. We base our MOOC content on the plots of a Chinese

[1] Promotion video: `shorturl.at/bcvIP`

classic, "The Romance of The Three Kingdoms". Originally, I wanted to use "Journey to The West" for this purpose, but my students convinced me that the "Romance of The Three Kingdoms" were very popular in the Mainland China as well as Japan especially in video games. There are many famous battles in "The Romance of The Three Kingdoms" which can be used as the background story and converted to different types of Discrete Optimization problems. For example, we can use teach techniques to help Liu Bei and Guan Yu to solve war related problems. We would go through such famous story scenes as "Oath at the Peach Garden" and "Judging Heroes Cooking Wine". The story is started with a Celestial Wise Guru who considered Liu, Guan and Zhang as heroes of their time, and presented them with a Magical Tablet. When Liu Bei encountered a problem, he could use the Magical Tablet to summon and communicate with two famous AI professors of modern time to help him solve the problem. This is the backbone of the storyline of the course.

Each video lecture of the MOOCs always begin with an animation telling a story to set the stage of a difficult Discrete Optimization problem using a scene from the "Romance of the Three Kingdoms". After the animation, learners would continue with regular lecture and learn some AI techniques from the two professors to solve the posted problem. We made two versions of the MOOCs: one in English and one in Putongua. It is still one-way teaching when students watch our lecture videos, but the animation should help set the stage and engage learners' interest. Each week (a module) is made up of several video lectures. At the end of a week, the two professors would give a debriefing session which is conversational in nature. Learners can see the two professors chatting with each other to discuss the development of the story plots as well as summing up what students should have learned in that week. This dialogue approach takes learners away from the serious one-way delivery mode momentarily every week.

In addition to watching the video lectures, learners would have to attempt two kinds of exercises each week: assignments and workshops. Assignments are for assessment purposes, in which learners would have to solve problem with computer programming using techniques they learn in the module. They also have to attempt a workshop exercise, the setting of which is similar to an assignment. The difference is that we would provide a "solution" video. Students would be encouraged to solve the problems themselves before watching the solution video, in which the two professors would try to analyze and solve the problem on the spot. Students could see how the professors solved the problems. We did not do any rehearsal at all and always attempted the problems afresh. We were conscious not to see the problems and then we solved the problem step by step on the spot, without deleting or editing what and how we did wrong. So the students would be able to see what mistakes we would make and how we would go about rectifying them. This is the process that learners found extremely useful for their learning.

How were these MOOCs designed and produced? Simply speaking, we listed all the knowledge points in the order of teaching needs, and matched them against the *scriptable moments* (or interesting story scenes) of "The Romance

of The Three Kingdoms". We needed a scriptwriter/animator who was familiar with the story line of the novel, and were lucky to find one. After a knowledge point was matched with a scene, professors and the scriptwriter just had to sit down and brainstorm to inject a Discrete Optimization problem into the scene. Problem creation sounds easy, but we spent a lot of time on it. Just like polishing a jade stone to perfection, there was no magic or shortcut to speed things up. The episodes were written with countless brainstorming meetings with caffeine injection. When students take our course, their learning experience will be like watching a movie. Therefore, we need to select a good story as the backbone of the movie as we wanted the students to be engaged. People like to identify themselves with heroes. We intend our learners to immerse themselves into the main characters and take the difficult problems as their own. They are motivated to try their best to solve the problems by learning the subject contents to be covered in the remainder of the videos. The story of "The Romance of The Three Kingdoms" serves a good basis for us to inject good stimulation and context into the learning of abstract mathematical concepts and algorithmic thinking.

Fable-based Learning (FBL) is problem-based [1] and immersive, and a form of Anchored Learning [4], in which learners are situated in an interesting and real-life scenario to enhance their learning experience. When students have to learn something new, they know they have to learn the technique to solve a specific problem. So there is a learning context in each lecture. They know what problem they need to solve so they need to learn the specific knowledge. That is, in each lecture, the teacher will give a problem at the beginning. With the story line, we hope to give students an immersive experience. That means students think they have become the characters of the story. For example, in teaching arithmetic, students will be taken to the marketplace to go shopping. So they will be motivated to learn basic addition and subtraction.

Some would say that FBL is essentially traditional case studies, which also provide a realistic and complex context for student learning. However, students usually have to jump from cases to cases. Such context switching can slow down learning. For example, we go to the supermarket when we teach addition today. We need to go to the factory floor to learn multiplication another day. In FBL, we use a single story to connect all learning contexts. In our MOOCs, all problems took place in "The Romance of The Three Kingdoms". This idea is actually not new. Back in the 2000s, we introduced the Folklore-based Learning approach [8], in which we created a prototypical game-based learning platform with story telling for teaching introductory to advanced probability concepts. FBL is essentially Folklore-based Learning without the game component. However, Folklore-based Learning was applied to only a few topics. This project is the first time story-telling is applied coherently in a large scale.

4 MOOCs Status and Learners' Feedback

In the first stage of the project, we created two MOOCs. One MOOC is roughly equivalent to the materials of one months workload in university teaching. The

MOOCs have both an English and a Chinese version. In March, 2016, I led a group of four persons to Melbourne for four months, including one animator/scriptwriter and my two PhD students as my assistants. UniMelb met us with pedagogical experts, project managers and an excellent film and production crew. We finished all videos, assignments, course outline, animation, and logo design, as required by Coursera. I developed all materials in English, and then my assistants translated them into Chinese. As there are two language versions for the MOOCs, Peter and I taught separately the English and Chinese versions respectively. Some videos (the module summaries and the workshop solutions videos) with dialogues between Peter and I would be made in English. Chinese subtitles were added in the post-production phase.

After we returned to Hong Kong, we still spent roughly half a year of post-production work. The two MOOCs were put online on Coursera in January and February in 2017 respectively. In August, 2017, we spent another three months in Melbourne to produce the third MOOC on the subject. The best story scenes of "The Romance of The Three Kingdoms" were used up. The new MOOC was based on selected stories from "The Book of Mountains and Seas" [2], "The Investiture of the Gods" [11] and "Journey to the West" [10], and was launched in May, 2018. Each of the three MOOCs lasts for four weeks, and is running on Coursera on a rolling basis.

The three MOOCs consists of 13 modules/weeks totaling 61 lecture videos, 3 MOOC introduction videos, 12 module summary videos, 14 live coding videos, 14 workshops and 12 assignments. That translates to 23h38m of high quality videos, which were produced in close to two and a half years. The MOOCs, including the grading of assignments, are completely free for learners, unless they want a certificate from Coursera in which case they have to pay a small fee.

Up to April 27, 2021, the MOOCs attracted the following enrollments.

	Visitors	Enrolled	Started	Completed
1	112,075	20,549	10,204	851
2	58,466	15,654	4,781	245
3	50,113	6,321	2,465	87

Learners came from 164 countries in 6 continents. The top 10 countries are USA, India, Germany, Australia, Canada, UK, Brazil, Hong Kong, France and China. We are able to promote Discrete Optimization to thousands of learners around the world, which is impossible by just lecturing in our classrooms alone.

We received top ratings from the learners for each of the three courses:

1. 87% 5 stars, 11% 4 stars and 1% 3 stars
2. 94% 5 stars and 6% 4 stars
3. 88% 5 stars and 9% 4 stars

Peter and I were rated as *Top Instructors* on Coursera during different period of time in 2020 and 2021. Coursera bestows the Top Instructors title on the top 10 instructors in each domain based on the instructor ratings given by the learner, where the Computer Science domain consists of 627 MOOCs.

Learners leave comments to MOOCs on Coursera. For our MOOCs, some liked our MOOCs because there was a different application in each video. Some found out the techniques taught in the MOOCs allowed them to solve many different types of problems. Some appreciated the story-based examples. Initially, we were a bit worried that we should probably use western stories as background for the English version of the MOOCs, but Peter did not think that there would be any problem since Chinese stories could be amazing too. Therefore, we also used "The Romance of The Three Kingdoms" for the English version.

Amongst all the comments we received, we shared the following one from 2018 with you. He went to a top AI conference in Australia in 2017. He heard of our courses at the conference and then looked them up. He was a key person of the top research funding agency in North America, and responsible for approving funding to AI research projects. It was a long one but we give the following summary.

> "*. . . I first became interested in MiniZinc when I attended CP/SAT/ICLP in Melbourne. I saw you both there, I think, but I did not have an excuse to meet you (I spent most of my time in ICLP). I am not a researcher in any of those communities. . . . Your course is excellent and engaging. Thank you for the care you have obviously put into the course design. I think I probably put much more time into this than I had anticipated, and yet I really enjoyed doing that because you managed to keep me on the edge of my abilities and comprehension of the language features, which I believe is really the place to be for learning such a skill. . . . The workshops were probably the best pedagogical devices for me for most of the course. . . .* "

He did not have much computer programming training but thought our MOOCs were truly engaging and challenging. He only planned to spend a little time on the MOOCs, but eventually found himself hooked and ended up spending much more time than anticipated. He liked the design of assignments much. He "felt sorry" after taking the courses since he started noticing his surroundings and found so many things not being optimized. In early 2020, I was attending another AI conference and the learner came looking for me to thank me in person. That was truly a special moment to meet a fellow learner from our MOOCs.

A natural question is whether FBL is transferable to other subject disciplines. We think that story telling can be used in highly technical courses emphasizing problem solving skills in general. The approach is good for students but can be a big challenge for teachers. The first challenge is to develop a story. It sounds easy but we spent a lot of time to match the knowledge point against the scriptable moments of the story which must follow a chronological order. Incorporating problems into the scriptable moments and story scenes naturally is another challenge involving both me and the scriptwriter while making the stories fun. The third challenge is to my teaching method. I had been accustomed to the traditional teaching mode for so many years by teaching the theories before mentioning applications. Now I had to come up with application problems first before teaching the definitions and theorems. This is problem-based approach.

It sounds easy but I had to do my lesson planning upside down and inside out. Before a teacher plans to adopt FBL, the teacher must ask whether (s)he can afford the time, labour and monetary cost.

5 Small Private Online Courses and Flipped Classroom

MOOCs allow learners from around the world to learn our subject matter. There are no reasons why we cannot bring the videos back to our classrooms to conduct *Small Private Online Courses (SPOCs)* [6]. With permission of CUHK, I was allowed to use the videos to teach in classrooms in a blended learning, with which classroom contact hours with students can be reduced by half. Many students took the course for the reduction in classroom hours and then some of them would regret.

In our SPOC setting, students have to complete all the learning activities of the MOOCs, which include learning from the videos, attempting the workshops and assignments, and participating in the online forum discussions. We have constructed an automatic grading system, to which students can submit their assignment multiple times. If students are not satisfied with the results, they can try again and resubmit. This motivated our students to improve their assignment submission attempts over and over. This encourages self discovery and self learning.

In addition, every student must also fill in an online "questionnaire" as part of the assessment. Some questions asked if the student had completed the various learning activities of the week. Some asked about simple concepts that they were supposed to have learned. Some would be more involved, requiring students to solve simple problems. These questionnaires serve as reminders and help students to do stocktaking, making sure that students are on track with their learning.

Even when the students were exempted from half of the classroom time, they still needed to come. We do away with traditional lecturing. In the flipped classroom [9], students would be encouraged to raise questions. If they stayed stagnant, I would ask them questions including those in the weekly questionnaire. I hoped to take the opportunity to correct their misunderstanding of some concepts. Also, more problems would be provided for students to solve. Sometimes, students form groups and solve problems together. Since the class size was small, students would have to answer questions and present problem solutions in turn. Students could critique each others' answers. Like other universities, CUHK has a system of course and teacher evaluation at the end of semesters. The score they gave us was quite good. I was particularly happy since students doing well in the course usually gave higher scores in the evaluation. In other words, those who did well in the course tended to like this teaching approach.

Students also gave written comments. In general, they enjoyed all the teacher-student interactions in the classroom, found the explanation clear and the teaching approach interesting, and students were encouraged to learn. However, why would some students regret taking the course? Although the class hours were reduced by half, students had to spend much more time and effort in learning.

They had to watch all the videos and then come to the class and answer my questions. They felt they had to spend a lot of time on the course. Some students did indicate that they preferred traditional classroom teaching.

6 Evaluation of SPOC and Limitations

The learning enhancement and research unit of the university (called "CLEAR") was invited to do more in depth analysis of students' responses to the new learning approach when the course was taught in 2018 and 2019. In 2018, CLEAR designed a questionnaire. In 2019, a focused group with students was organized..

Firstly, we wanted to see how students compared flipped classroom teaching and traditional classroom teaching, and which one they would prefer. What did they think of flipped classroom teaching? What did they think of problem-based teaching and story-based teaching? Finally, we would like to see if the weekly questionnaires were useful. The results showed that in general students thought the course brought nice learning experience. Students were also satisfied with the quality of the teaching materials of the MOOCs. To them, quality was of paramount importance as it would affect the learning result significantly. They also found the bi-weekly classroom activity very important. Some students indicated that they preferred traditional classroom teaching. Most of the students thought that they could catch up with the course progress. In particular, they found the weekly questionnaires very useful.

Students had their chance to evaluate the course and the teacher. We evaluate students too by the course assessment, which includes the regular assignments and a final examination. Looking at the marks, I found that students in the class could be roughly put in two bands. Students in the top band are the high achievers and attended 60% or more of the classroom meetings. Students in the low band were the ones attending less than 60% of the class meetings. The results are not surprising since those attending more classes are the ones who (a) spent more time in the subject and (b) were the more motivated to learn.

I understand that this sharing of teaching experience has limitations. I only taught one class every year. In 2018 and 2019, there were 17 and 22 students respectively. In the first class every year, I usually tried to scare students off so that I did not have to mark so many examination papers. However, the enrollment kept on increasing. Another limitation was that students did not take the course for no reason. They took the course because they saw our promotion and liked the approach. They should like the subject too. Thus, the sampling was not random. I did not have a chance yet to implement a research in which I could have both a controlled group and an experimental group. Students in the controlled group would be taught in the traditional approach.

7 Concluding Remarks

The MOOCs have been deployed for only a few years. It might be a bit early to draw any definitive conclusions on the effectiveness of the FBL approach. In

a sense, we are conducting a large scale experiment which is still ongoing. We encountered hiccups during the design and development of the pedagogy and the MOOCs, but the multi-cultural team overcame our differences and resolve the encountered difficulties. Building a high quality FBL course is challenging and requires a great deal of planning and strong communication between scriptwriters and educators. But, at least for us, the process was immensely rewarding, and it continues to attract highly motivated learners of the materials.

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