# Educational Evaluation in the PKU SPOC Course "Data Structures and Algorithms"

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## Abstract
In order to learn the impact of MOOCs, we conducted a SPOC experiment on the course of Data Structures and Algorithms in Peking University. In this paper, we analyze student online activities, test scores, and two surveys using statistical methods (t-test, analysis of variance, correlation analysis and OLS regression) to understand what factors will foster improvements in student learning. We find that the "SPOC + Flipped" is a helpful mode to teach algorithm, time spent on the course and students' confidence had a positive impact on learning effect, and SPOC resource should be made full use of.

## Author Keywords
SPOC; Flipped Classroom; Algorithms; Education

## ACM Classification Keywords
K.3.0 Computers and Education

## Introduction
A SPOC (Small Private Online Course) [1] was proposed by Armando Fox in 2013, which was referred as a version of MOOC and used locally by only on-campus students. And Fox argued that a SPOC can supplement the classroom experience by combining with online resources [2]. SPOCs can take the online approach to smaller, targeted and revenue generating classes [3].

Konstan et al. tried a flipped classroom model and constructed an OLS (Ordinary Least Squares) regression model to predict the completion, knowledge gains and final grades [4].

As the students of a SPOC course usually come from the same school or university, the difference among learners is much smaller. Reducing the influence from the background and purpose of the students, the analysis of the course is more reliable. Our analysis in this paper will show a positive meaning for the application of SPOCs.

In 2014 spring, we conducted an experiment on the course of Data Structures and Algorithms in Peking University (PKU in short) to evaluate the learning effectiveness of SPOCs. In particular, 828 undergraduate students majoring in science or engineering took this course: 397 of them attended the five SPOC classrooms, and the others attended the five traditional classrooms, which means they didn't use the online materials.

We collected the data through students' online behaviors and the surveys. We aimed to find out how to improve students' learning effectiveness.

## Research Questions

We will analyze the data of the course and discuss the following issues in details.

1. Compared with the students of traditional classrooms, did the students of SPOC classrooms who used online materials perform better?

2. To what degree does the factors play a role in students' learning effect and why did them work?

3. Among the students of SPOC classrooms, did the students who were asked to finish the online quizzes and assignments make greater progresses than those who just used online quizzes and assignments as optional supplements?

## Statistical Analysis Results
### The impact of SPOC learning mode on learning effect

In order to measure how much students had learned from the course, we collected the score of their final examination. We divided the final examination into two parts, concept questions and algorithm questions. The former part focus on students' memorizing, while the latter one focus on students' understanding.

We used the t-test to analyze the performance difference between the students of SPOC classrooms and traditional classrooms in the concept questions and algorithm questions.

We find that the performance of the concept questions of two kinds of classrooms may not have any difference (P = 0.067), but there might be a difference between the performances of algorithm questions of two classrooms (P = 2.97E-08). Namely, the performance of algorithm questions of students of SPOC blended learning classroom (the mean is 33.99) is significantly better than that of the students of traditional classroom (the mean is 31.35). And the score variance of concept questions and algorithm questions of SPOC classroom is smaller than that of traditional classroom, which means that the students of SPOC classroom have better overall appearance and more stable performance. The average score of concept/algorithm questions of ten classrooms are shown in Figure 1.

The students were partitioned into the ten classes based on their schools, and the students of SPOC classroom perform better in the College Entrance Examination in average. Since the grade of Class B2 far lower than others, we hold another t-test excluding class B2, and the P-value is 0.027, which also shows that SPOC classroom perform better.
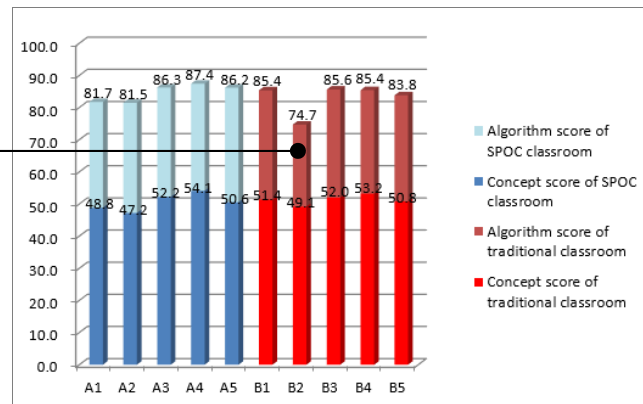


**Figure 1.** The comparison of the final scores between different classrooms

So, the t-test above to some extent shows that the learning mode of SPOC may help students grasp the knowledge more deeply.

### Factors that impact on the students' learning effect

Students' learning effect will be influenced by many aspects. In order to understand better what kind of factors may impact learning effect significantly or what kind of characteristics better students owned, we used an OLS regression model to fit the students' final score, as an evaluation of the final learning effect of students. The regression was based on four kinds of features, students' learning background, students' basic information, students' attitude to the course, and the level of effort of the students.

According to the students' online learning activities, their offline learning situation (fetched by two questionnaires) and the performance in the final exam, we took the intersection of students who attended all the activities above as the sample.

We find that the total time of students spent in the course has a significant positive effect on students' learning effects (Co = 0.845****), which means that the students' efforts were rewarded. In addition, both the confidence of students at the beginning and the end of the course had a significant positive impact on learning effect (Co = 2.595*, 2.029*). Confidence motivates students to learn, and it is also an evaluation of students' own learning situation. Finally, we find whether he or she was a freshman had a significant positive impact on the learning effect of students (Co = 3.733*). Because this course is delivered for freshman, they usually communicated with each other, which would produce the effect of collaborative learning. And it also may be due to that seniors focused more on the professional courses of study.

Finally, note that the adjusted R-square is only 0.174, which means that some factors that influence the learning effect had not been taken into account or observed, such as collaborative learning and review time. The discussion between students may deepen the understanding of knowledge, help students learn from each other and play a supervisory role. The review before the final exam helps to consolidate the knowledge. We plan to collect these information through questionnaires in the next term of the course.

### The impact of SPOC resource utilization

In order to further analyze the impact of SPOC teaching mode, we divided the five SPOC classrooms into flipped classrooms and resource utilization classrooms based on the actual teaching situation. The main difference is that the online quizzes and programming labs were rigidly required to complete in flipped classroom, while the quizzes and programming labs are supplement of learning materials in resource utilization classroom. In

| | SPOC flipped classroom | SPOC resource utilization classroom |
|---|---|---|
| Mean | 0.30 | -0.24 |
| Variance | 1.05 | 0.88 |
| N | 154 | 192 |
| Degree | 344 | |
| P-value | 4.12E-07 | |

**Table 1. T-test for the difference in means between SPOC flipped classroom and SPOC resource utilization classroom**

general, the latter's utilization of SPOC resources was not sufficient. Because *Introduction to Computing* was taught in different forms among students, we measured students' progresses by their z-scores of the courses.

We used the t-test to analyze the progresses difference between the students from two kinds of classrooms, to see whether resource utilization of SPOC impacted on students' learning effect significantly. The progress was defined as follows. The progress of a student equals to his z-score of our course minus his z-score of *Introduction to Computing*, which is the prerequisite of our course. The result is shown in Table 1.

The result shows that the average progress of z-score in flipped classroom is 0.30, which shows the general increase in student grades, while the average progress of z-score in resource utilization classroom is -0.24, which shows a slight decrease of student grades. And the difference between the two kinds of classrooms is significant, for the P-value is 4.12E-07.

Therefore, the analysis to some extent shows that if students can make full use of SPOC platform resources, including video resources, after-school practices, they will have a significant improvement on learning effect.

## Conclusion

This paper presents a SPOC experiment of Data Structures and Algorithms in Peking University, and gets the following findings:

 *"SPOC + Flipped" is helpful in teaching algorithms.* Since the blended "SPOC + Flipped" teaching mode asked students to preview the lecture before the class, it gives students more opportunities to discuss with teachers and classmates, so that they can understand the knowledge better.

*Students' time spent on the course was rewarded and the confidence of students is important in learning.* Thus, we should encourage students to pay more efforts and put more positive words in their assignment comments.

*Making full use of SPOC resources improved the learning effect.* The quizzes and assignments were carefully chosen and contains most knowledge points, which would correct students' inaccurate understanding, so that students who practices more will perform better.

Through the analysis, our research shows a positive meaning for the application of SPOCs.

## Acknowledgements

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