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Comparative Analysis of the Learning of Oral Anatomy and Physiology Under Different Teaching Approaches

Huiling Sun, Minqi Li, Wenqing Zhang

Key Laboratory of Shaanxi Province for Craniofacial Precision Medicine Research of Stomatology College, Xi'an Jiaotong University, Xi'an, P. R. China

Email address:
sunhuil@mail.xjtu.edu.cn (Huiling Sun), li_minqi829@163.com (Minqi Li), 2065876766@qq.com (Wenqing Zhang)

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Abstract: The purpose of this study is to analyze and compare the influence of traditional lecture, MOOC online learning and flipped classroom on the learning of the course Oral Anatomy and Physiology. We compare and analyze the teaching on three cohorts of undergraduate dental students: students from Grade 2012 (n = 38, traditional lecture cohort), students from Grade 2014 (n = 64, MOOC online teaching cohort) and students from Grade 2018 (n = 60, flipped classroom cohort). We study the teaching by analyzing the scores of tooth identification, tooth waxing during the course, and the final exam after the course. We also administered a Student Satisfaction Questionnaire Survey to gather feedback on the MOOC online learning and flipped classroom approaches. Our results are as follows: (1) There were no statistically significant differences among the short-term assessments of the students (tooth identification, tooth waxing and the final exam) under the three different teaching approaches. (2) Flipped classroom promoted students' autonomous learning ability and their ability to cooperate with others. Compared to traditional teaching, MOOC online learning was found to be more conducive to the mastery of hands-on skills and the cultivation of autonomous learning ability among students. Additionally, the flipped classroom approach, which blends MOOC online and classroom offline learning, helped to promote students' autonomous learning ability and their ability to cooperate with others. It converted students' learning behaviors and study habits from passive learning to active learning. The learning experiences of students transformed from a teacher-centered classroom and rote learning in the past, to peer-assisted learning and interactive learning at the present, facilitating the internalization of learner's knowledge. Online learning could foster students' sense of responsibility and autonomous learning ability, making it a valuable approach to promote.

Keywords: Flipped Classroom, MOOC, Teaching Effectiveness, Oral Anatomy and Physiology

1. Introduction

MOOC (Massive Open Online Course) refers to a brand-new teaching approach generated by the integration of Internet technology and education in the context of "Internet Plus" model [1]. The emergence and development of the MOOC revolutionized educational ideas and educational formats, enabling students to choose their favorite courses through the Internet. Nowadays, MOOCs have been widely applied in medical education, such as clinical medicine [2, 3], stomatology [4], radiology [5], and ophthalmology [6] and so on. Nevertheless, at present, controversies remain in the current development of MOOC [7].

Flipped classroom, also known as inverted classroom, describes the blending of modern multimedia technology and traditional lecture-based learning, which innovates traditional lectures to entice the autonomous learning ability of the students [8]. In recent years, flipped classroom has aroused wide concerns and has become widespread. Students' learning has improved via the collaborative effect of digital media and face-to-face classroom, and students' classroom participation has increased to a certain extent with the application of flipped classroom [9-14].

Oral Anatomy and Physiology is a foundation course for stomatology. There are three learning objectives of the Dental Anatomy module of the course: 1. Students can be able to

recognize the characteristics of tooth morphology. 2. Students can be able to identify natural dentition. 3. Students can be able use their knowledge of dental anatomy to create tooth morphology in waxing exercises. This paper examines the learning of three different teaching approaches of Oral Anatomy and Physiology, namely traditional lecture, MOOC online learning and flipped classroom, in order to improve teaching by making use of the advantages and disadvantages of different teaching approaches in the future.

2. Participants and Methodology

2.1. Participants

Students from Grade 2012 in their first semester of academic year 2015-2016 (n = 38, traditional lecture cohort), Grade 2014 in their first semester of academic year 2017-2018 (n = 64, MOOC online teaching cohort), and Grade 2018 in their second semester of academic year 2019-2020 (n = 60, flipped classroom cohort) from the Stomatological College, Health Science Center, Xi'an Jiaotong University. The course they study was Oral Anatomy and Physiology (Course code: STOM3010).

2.2. Teaching Approaches

2.2.1. Traditional Lecture Cohort

The Dental Anatomy module consists of six lectures: Overview Introduction, Morphology of Incisors and Canines, Morphology of Premolars, Morphology of Molars, Morphology of Pulp Cavity and Deciduous Teeth (Table 1). Students were informed that they would be asked about what they had learned from the last class during the class session. During the lectures, students were required to identify the morphology of each tooth surface with tooth models. At the end of the lectures of the morphology of each tooth surface, students were required to draw two-dimensional sketches of the tooth surface during the class within a given time. After each lecture, there would be a laboratory session of tooth waxing (3#, 8#, and 30#) and tooth shaping (5#), that is, students would create tooth morphology with the knowledge of dental anatomy they had learned. Natural dentition identification assessment was given at the end of the Dental Anatomy module, and a written exam was given at the end of the course.

2.2.2. MOOC Online Teaching Cohort

Students were required to complete half of the above lectures, Morphology of Premolars, Morphology of Pulp Cavity and Deciduous Teeth (Table 1), through MOOC online learning. Other lectures, Overview Introduction, Morphology of Incisors and Canines, Morphology of Molars, were still conducted in traditional manners.

Each student was required to sign up for an account on the platform of MOOC of Xi'an Jiaotong University. MOOC online learning videos were prerecorded, which shared the same content as the traditional lectures. MOOC online learning is characterized by videos that last about 10 minutes, and each video lectures on a certain type of tooth. Each video comes with pop quizzes and chapter quizzes, and a final exam at the end of the course. Students were required to complete the videos and the assessments, and they were informed that the data of learning on the platform would be recorded and counts against their final scores.

2.2.3. Flipped Classroom

Flipped classroom was carried out in the following lectures: Morphology of Incisors and Canines, Morphology of Premolars, Morphology of Molars, which were the same as the above MOOC online learning lectures (Table 1). Other lectures, Overview Introduction, Morphology of Pulp Cavity and Deciduous Teeth, were still conducted in traditional manners.

Flipped classroom consisted of self-study videos, prior-to-class group discussion, and in-class presentation. Assignments and announcements were sent to students via Rain Classroom (An online teaching software developed by Tsinghua University and XuetangX). Students were required to complete the self-study videos and the assignments within a given time. During the in-class activity, students were divided into 9 groups, each group presented their learnings from the videos, what the key and difficult points were, what measures they took to solve the difficulties and what related literature they referred to. Each student was asked to participate in the group presentation. There were three flipped classroom presentations in the semester; the instructor at the end of each presentation gave comments and feedback.

Table 1. *The teaching session, teaching approaches, instructor, participants and teaching weeks of the lectures of the Dental Anatomy Module.*

	Overview Introduction	**Incisors and Canines**	**Premolars**	**Molars**	**Pulp Cavity**	**Deciduous Teeth**
Grade 2012 (Week 1-9)	Traditional teaching (Sun)	Traditional teaching (Sun)	Traditional teaching (Sun)	Traditional teaching (Sun)	Traditional teaching (Sun)	Traditional teaching (Sun)
Grade 2014 (Week 1-9)	Traditional teaching (Sun)	Traditional teaching (Sun)	MOOC (Sun)	Traditional teaching (Sun)	MOOC (Sun)	MOOC (Sun)
Grade 2018 (Week 8-14)	Traditional teaching (Sun)	Flipped classroom (Sun)	Flipped classroom (Sun)	Flipped classroom (Sun)	Traditional teaching (Sun)	Traditional teaching (Sun)

2.3. Teaching Evaluation

The evaluation of learning under three teaching approaches adopted the same marking criteria. The final assessment of the students consisted of the scores of tooth identification, tooth waxing and tooth shaping, the final exam, MOOC online learning tasks, flipped classroom activities and so on. Tooth identification assessment was given at the end of

the morphology of the permanent teeth lectures. Student participated in the tooth identification examination in which each student had to identify 14 natural teeth (out of 5 points) within a given time. Tooth waxing included waxing up teeth of 2 times the size of the 3#, 8# and 30#. Tooth shaping included the pasting of occlusal surface of 2 times the size of 5# teeth. The same instructor evaluated students on the morphology of the buccal and labial surface, lingual surface, mesial surface, distal surface, incisal edge and occlusal surface (5 points /tooth, out of 20 points). Students were given enough time to complete each task and were graded after they finish. The final written exam was given at the end of the course. The scores of tooth identification, tooth waxing and tooth shaping, final exam, MOOC online learning tasks, flipped classroom activities account for 5%, 20%, 45%, 10%, 20% of the final score respectively.

2.4. Data Analysis

The data was analyzed by Prism 6.0 (GraphPad Software, La Jolla, CA 92037 USA) statistical software. The results of tooth identification, tooth waxing and the final exam under three different teaching approaches were analyzed with One-way ANOVA. The significant level was set as alpha = 0.05.

3. Results

3.1. Teaching Under Different Teaching Approaches

The scores of tooth identification, tooth waxing and the final exam of the three cohorts were analyzed and compared for statistical analysis, among which Grade 2012 was the traditional cohort, Grade 2014 was the MOOC online teaching cohort, and Grade 2018 was the flipped classroom cohort.

3.1.1. Traditional Cohort

Grade 2012 was the traditional cohort. According to the statistical analysis, the average score of the Grade 2012 in tooth identification was 3.543 (out of 5), the average score of tooth waxing was 16.01 (out of 20), and the average score of the final exam was 85.74 (out of 100) (Figure 1).

3.1.2. MOOC Online Learning Cohort

Grade 2014 was the MOOC online learning cohort. There was no statistical difference between MOOC online learning and traditional teaching in the scores of tooth identification, tooth waxing and final exam according to the statistical analysis (Figure 1).

3.1.3. Flipped Classroom Cohort

Grade 2018 was the flipped classroom cohort. According to the statistical analysis, there was no statistical difference between flipped classroom and traditional lecture cohort in the scores of tooth identification, tooth waxing and the final exam. It is suggested that flipped classroom had no influence on the scores of tooth identification, tooth waxing and the final exam (Figure 1).

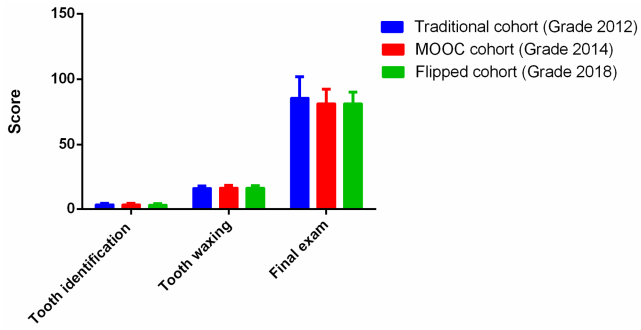

Figure 1. *Test results of the three grades.*

3.2. Student Satisfaction Questionnaire Survey

We conducted a questionnaire survey for Grade 2014 (Table 2) and Grade 2018 (Table 4), adopted MOOC online learning and flipped classroom learning，respectively. The details and the results of the questionnaire are shown in the following table (Table 2, Table 3). The questionnaire indicates some cognitive differences of students in MOOC online learning and flipped classroom, and it may be one of the reasons for the lack of significant differences in students' academic performances (Table 2).

Table 2. *The results of the questionnaire survey on MOOC online learning for Grade 2014.*

Student satisfaction	Proportion (Grade 2014)
MOOC online learning is very helpful for the study of Oral Anatomy lectures.	75%
MOOC online learning is very helpful for Oral Anatomy laboratory sessions.	66%
MOOC online learning accounts for a reasonable proportion in the class sessions.	55%
The proportion on MOOC online learning should be reduced	34%
I am willing to choose the blending of MOOC and traditional lectures.	81%
I would like to learn extracurricular knowledge on MOOC.	22%
The relationship between MOOC and traditional lectures: mainly traditional lectures with MOOC assisted.	59%
I can acquire the knowledge I want from the course: basically/completely.	63%/38%
Time management of the course: tight/acceptable.	61%/38%
Applicability of assignments and assessments: good/general.	66%/31%
Difficulty of the course: difficult.	52%
Expression and explanation ability of the instructor: good/general.	97%/3%
The instructor could capture the interest and attention of the students: usually/occasionally.	94%/5%
The frequency of MOOC used before this course: frequently/occasionally.	17%/83%
Willingness to promote MOOC learning: ≥ 90%	44%

Table 3. *The results of the questionnaire survey on flipped classroom for Grade 2018.*

Student satisfaction	**Proportion (Grade 2018)**
You can master the theory of the course more easily with the pre-class study period of flipped classroom ()	
A Completely agree	19.35%
B Relatively agree	30.65%
C Basically agree	33.87%
D Relatively disagree	16.13%
E Completely disagree	0.00%
You can quickly grasp the key points of the laboratory sessions with the pre-class group discussion ()	
A Completely agree	16.13%
B Relatively agree	30.65%
C Basically agree	45.16%
D Relatively disagree	8.06%
E Completely disagree	0.00%
What is the proportion of flipped classroom in class sessions that you hope ()	
A ≥ 80%	1.61%
B 60%-80%	16.13%
C 40%-60%	19.35%
D 20%-40%	38.71%
E < 20%	24.19%
What is the proportion of flipped classroom in laboratory sessions that you hope ()	
A ≥ 80%	9.68%
B 60%-80%	22.58%
C 40%-60%	32.26%
D 20%-40%	30.65%
E < 20%	4.84%
Compared with traditional teaching, how much time do you spend in flipped classroom to achieve the same learning result ()	
A A lot	27.42%
B A little more	50.00%
C Relatively the same	19.35%
D Relatively less	3.23%
E Much lesser	0.00%
For the following learning styles, you prefer ()	
A Traditional learning	51.61%
B Online learning	17.74%
C Flipped classroom	25.81%
D Others	4.84%
Flipped classroom improves your autonomous learning ability compared with traditional lectures ()	
A Completely agree	20.97%
B Relatively agree	43.55%
C Basically agree	27.42%
D Relatively disagree	8.06%
E Completely disagree	0.00%
Which way do you prefer when flipped classroom is applied to laboratory sessions ()	
A Pre-class videos + discussion→laboratory sessions	22.58%
B Pre-class videos + discussion→laboratory sessions→group sharing and peer learning	30.65%
C Pre-class videos→laboratory sessions→group sharing and peer learning	32.26%
D Pre-class videos + self-practice→group evaluation and discussion→laboratory sessions	4.84%
E Pre-class videos + self-practice→group evaluation and discussion→laboratory sessions→discussion and summary	9.68%
Learnings from flipped classroom ()	
A Flipped classroom worked well for the learning of lectures	4.84%
B Flipped classroom worked well for the learning of laboratory sessions	56.45%
C Flipped classroom worked well for the learning of lectures and laboratory sessions	33.87%
D Flipped classroom did not work well for the learning of lectures or laboratory sessions	4.84%
How willing are you to support the promotion of flipped classroom ()	
A ≥ 90%	16.13%
B 50%-90%	45.16%
C 10%-50%	30.65%
D < 10%	8.06%
The learnings from flipped classroom of this course is/are () (you may choose more than one option)	
A Mastery of theories	46.77%
B The ability of consulting references	67.74%
C The ability to cooperate with others	62.90%
D Autonomous learning ability	77.42%
E Others	9.68%

4. Discussion

Pedagogic approaches of medical education have been changing, and some new teaching strategies have emerged to promote students' learning experiences, understanding of concept and application of knowledge. The purpose of this study was to compare students' learning on three assessments (tooth identification, tooth waxing and the final exam) of Oral Anatomy and Physiology among students in the traditional lecture cohort, MOOC online learning cohort and flipped classroom cohort.

4.1. The Construction and Application of MOOC

The MOOC construction of Oral Anatomy and Physiology started at the end of 2015 and was completed in June 2016. After one year of trial and modification, it began to be applied to the teaching of undergraduate students in September 2017 under the arrangement of the Administrative Department for Undergraduate Education of Xi 'an Jiaotong University. MOOC online learning requires students to complete the learning sessions on the platform within a given time, and students are motivated to complete the online learning tasks for their study process counts towards the platform data and a certain proportion of the final assessment. This self-study period has cultivated the autonomous learning ability of the students. In order to further, explore MOOC online learning, with the support of the Administrative Department for Undergraduate Education of the university, flipped classroom was adopted in the second semester of 2018-2019 academic year and the second semester of 2019-2020 academic year. In 2018-2019, we attempted the same MOOC online learning, and in 2019-2020, we adjusted the learning content of flipped classroom based on the experience of the previous year. This paper only discusses the learning after the adjustment (Morphology of the permanent teeth). Flipped classroom required students to complete MOOC videos and consult related literature prior to the class, while during the class, students worked in small groups to report what they had learned from the online learning session, discuss the key points and difficulties of learning and their solutions, and present the literature they had referred to. The contribution of each member in the group was required to be reported to ensure the effectiveness of the lectures and students' participation.

4.2. Determination and Significance of Teaching Evaluation

Previously described, there were three main learning objectives in the Dental Anatomy module of Oral Anatomy and Physiology, memorizing the characteristics of tooth morphology, identifying natural dentition, and recreating tooth morphology in waxing exercises. These learning objectives follow curriculum guidelines of Oral Anatomy and Physiology by Okeson and Buckman, which provides essential cognitive skills and promotes psychomotor skills [15]. In the Oral Anatomy and Physiology course, tooth identification, tooth waxing, and the final written exam scores were important measurements in the learning of the Dental Anatomy module. The results of these three evaluations reflected the students' learning competency of the Dental Anatomy Module.

4.3. Cause Analysis of Differences in Teaching Under Different Teaching Approaches

Statistical analysis showed that there was no statistical difference between the scores of tooth identification, tooth waxing and the final exam. The scores were divided into high (≥ 90%), middle (≥ 77%) and low (< 77%) and the proportion of students in each score range (Table 4) and the number of students (Table 4) were analyzed. More students in the flipped classroom and MOOC cohort were categorized into the high score range in tooth waxing compared with the traditional lecture cohort, while also more students in the flipped classroom and MOOC cohort fell into the low score range in tooth identification and the final exam than that of traditional lecture cohort. As the videos of tooth waxing could be watched repeatedly, students who were willing to improve could take advantage of the fact that videos of tooth waxing could be watched repeatedly, thereby enhancing their academic performance. However, for students with a low level of self-discipline, it was difficult to ensure the completion of MOOC and flipped classroom self-study tasks. This could be the reason why they scored lower in tooth identification and the final exam. These results suggest that flipped classroom is more applicable for students with higher autonomy.

Surprisingly, the results were different from that of Chutinan S [16] et al. According to the results of Chutinan S, flipped classroom improved the score of tooth waxing, but had no effect on the score of tooth identification and the final exam. However, in this study, flipped classroom had no effect on the scores of tooth waxing, tooth identification and the final exam. This may be due to the details of how flipped classroom was carried out and the differences of educational backgrounds of students from different countries.

Table 4. *The proportion of students in each score range.*

Score	Assessments	Grade 2018 (flipped classroom cohort)	Grade 2014 (MOOC cohort)	Grade 2012 (traditional lecture cohort)
High (%)	Tooth identification	4(60) = 6.7	6(64) = 9.4	3(38) = 7.9
	Tooth waxing	9(60) = 15	16(64) = 25	4(38) = 10.53
	Final exam	11(60) = 18.33	18(64) = 28.13	21(38) = 55.26
Middle (%)	Tooth identification	6(60) = 10	6(64) = 9.4	9(38) = 23.68
	Tooth waxing	34(60) = 56.67	32(64) = 50	24(38) = 63.16
	Final exam	34(60) = 56.67	25(64) = 39.06	10(38) = 26.32

Score	Assessments	Grade 2018 (flipped classroom cohort)	Grade 2014 (MOOC cohort)	Grade 2012 (traditional lecture cohort)
Low (%)	Tooth identification	50(60) = 83.33	52(64) = 81.25	26(60) = 68.42
	Tooth waxing	17(60) = 28.33	16(64) = 25	10(38) = 26.32
	Final exam	15(60) = 25	21(64) = 32.81	7(38) = 18.42

4.4. The Advantages and Disadvantages of Different Teaching Approaches and Their Improvement

Traditional lecture is teacher-centered, transmissive classroom. However, MOOC online learning and the blending of online and offline learning (flipped classroom) are all based on the active learning of student-centered classroom. MOOC online learning is more conducive to the cultivation of students' autonomous learning ability and the mastery of experiment skills, while flipped classroom is more helpful for the improvement of students' autonomous learning ability, presentation skills and cooperative ability.

The limitation of this study lies in the difference of the number of students. The number of students enrolled in our course every year is fixed, in previous years the number was relatively lesser and has increased in recent years. It is not convincing that the difference in student numbers is adequate to affect the evaluation of the study. However, if the numbers of students in the three cohorts were equal, the results would be a more accurate reflection.

5. Conclusion

In this study, we compared students' learning under three teaching approaches in order to reflect the influence of MOOC and flipped classroom on students' learning, with the aim of making targeted improvements and perfecting course design in the future. The emergence of MOOC has diversified teaching approaches and realized student-centered teaching and learning, which focus on cultivating students' sense of responsibility for learning, self-learning habits, and autonomous learning abilities. We hope that these new teaching approaches can be perfected, improved, and promoted in teaching practice.

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