

# Coronavirus Disease 2019 Knowledge Acquisition and Retention: a Flipped Classroom Based on Micro-learning Combined with Case-based Learning in Interns

Qiaohui Qian (✉ [zp\\_qianqh@sumhs.edu.cn](mailto:zp_qianqh@sumhs.edu.cn))

Shanghai University of Medicine and Health Sciences <https://orcid.org/0000-0003-4087-3028>

Jiangxia Zhao

Shanghai University of Medicine and Health Sciences

Fei Xue

Shanghai University of Medicine and Health Sciences

Fengjiao Zhang

Shanghai University of Medicine and Health Sciences

---

## Research article

**Keywords:** Coronavirus Disease 2019, Blended learning, Flipped classroom, Micro-learning, Case-based learning

**Posted Date:** July 7th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-38263/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

---

# Abstract

## Background:

Since medical school affiliated hospitals suspended the internship rotation during Coronavirus Disease 2019 (COVID-19) pandemic period in China. Determining an effective and available approach for interns learning new disease knowledge becomes an important challenge in affiliated hospitals. We explored a blended learning approach, a flipped classroom based on micro-learning combined with CBL, in interns learning COVID-19 knowledge using prospective randomized study.

## Methods:

During COVID-19 pandemic period in China, 74 final-year undergraduate interns who were scheduled to rotate in our affiliated hospital in academic year 2019-2020 were randomized to a flipped classroom or standard classroom with 37 participants in each classroom group during a 120-minute live online COVID-19 curriculum utilizing the same Network Teaching Platform provided by our university. The standard classroom group utilized traditional lecture, while the flipped classroom group applied micro-learning combined with CBL. We compared the effect of both formats on COVID-19 knowledge acquisition and the impact on clinical practice attitude.

## Results:

All 74 interns (100%) responded pretest, posttest and retention test, and completed the questionnaire online. Both formats significantly improved COVID-19 knowledge acquisition at the conclusion of online COVID-19 curriculum. Interns' knowledge test scores including total score and scores of five knowledge dimensions of COVID-19 were significantly higher in the flipped classroom group than those in the standard classroom group ( $P < 0.05$ ). Compared with interns in the standard classroom group, interns in the flipped classroom group performed better in retention test and had a significantly more positive clinical practice attitude ( $P < 0.05$  in all items).

## Conclusions:

A flipped classroom based on micro-learning combined with CBL showed greater effectiveness in COVID-19 knowledge gain in final-year undergraduate interns and made their attitude toward clinical practice more positive.

# Background

In December 2019, cases of serious illness causing pneumonia and death were first reported in Wuhan, the capital of Hubei, China [1]. The World Health Organization (WHO) announced the official name of the disease as "coronavirus disease 2019 (COVID-19)". Affected by this COVID-19 pandemic, schools in China including medical schools were closed during the national concern public health emergency. Affiliated hospitals also suspended the internship rotation. However, one of the "quality standards" of current World Federation for Medical Education (WFME) Basic Medical Education (BME) is "continuous renewal", which requires the medical school should modification of the intended educational outcomes of the graduating students in accordance with documented needs of the environment they will enter. The modification might include clinical skills, public health training and involvement in patient care appropriate to responsibilities encountered upon graduation [2].

An affiliated hospital is an integral part of the medical school and has the obligation and responsibility to undertake the teaching work of relevant clinical new knowledge. Knowledge learned in affiliated hospital during the rotation period of the graduating students will provide supports for their lifelong learning and development. Determining an effective and available approach for interns learning new disease knowledge becomes an important challenge in affiliated hospitals. Beneficial effects have been found in empirical studies of the flipped classroom approach [3], micro-learning [4] or case-based learning (CBL) [5] in some health profession educations including medical education.

We explored a blended learning approach, a flipped classroom based on micro-learning combined with CBL, in interns learning COVID-19 knowledge using prospective randomized study. We hypothesized that it would result in improved COVID-19 knowledge acquisition and retention, compared to a traditional mode.

# Methods

## Setting and Participants

We invited 74 final-year undergraduate interns to participate this study. All participants were scheduled to rotate in our affiliated hospital in academic year 2019–2020 and the progress of their internship was basically consistent. In the period of this study, they were suspended clinical practice and stayed at home because of the COVID-19 outbreak and pandemic.

## Design

This was a prospective, controlled educational research study. Using the random number table, participants were divided into a flipped classroom or standard classroom with 37 participants in each classroom group. Figure 1 displays our research design and interventions.

## Interventions

Both flipped classroom and standard classroom utilized the Network Teaching Platform built and provided by Shanghai University of Medicine and Health Sciences to carry out the instruction. Educational content of our COVID-19 curriculum was from "Program of Diagnosis and Treatment of COVID-19 (trial 7th edition)" issued by National Health Committee of the People's Republic of China [6]. The total lecture period was set up as 120 minutes long in each group. A teaching team consisted of 3 clinical teachers was responsible for both formats of 120-minute live online COVID-19 curriculum. To maintain consistency between the two groups, one teacher prepared all teaching materials and gave demonstration lectures for both formats. The other two teachers held the live online curriculum respectively at the same time during the intervention protocol. Materials were peer-reviewed by all teachers before live online instruction. The demonstration lecture using traditional teaching was recorded and decomposed into micro-lesson videos. A total of 12 videos were developed, each of which focused on one or two learning points and controlled within 10 minutes.

The standard classroom group utilized traditional lecture, while the flipped classroom group applied micro-learning combined with CBL. The standard classroom group's live online instruction consisted of 115-minute lecture given by clinical teacher on COVID-19 utilizing PowerPoint (PPT) slides, followed by 5 minutes for intern questions. The flipped classroom group's live online instruction consisted of 120-minute discussion on typical clinical cases of COVID-19 guided by the teacher including in-class interactive questions responded by interns.

One week before the live online COVID-19 curriculum, we uploaded lecture PPT slides or micro-lesson videos respectively for participants in standard classroom group or those in flipped classroom group to preview or self-study. A knowledge pretest was administered before classroom division, a knowledge posttest immediately at the conclusion of their online COVID-19 curriculum, a questionnaire following the posttest, and a retention test 2 months later. Pretest, posttest, retention test and questionnaire were delivered at the same time in the two groups on the Network Teaching Platform.

#### Data Collection

We collected the demographic characteristics of interns when the participants were invited. A 25-item multiple-choice knowledge test on five dimensions of COVID-19 consisted of clinical manifestations, etiological detection methods, serological detection antibody titer characteristics, diagnostic criteria, and clinical typing was developed to measure the knowledge benchmark (pretest), acquisition (posttest) and knowledge retention (retention test). The total score of the knowledge test was set as 100 and composed of five dimensions with 20 per dimension. For clarity, length, and difficulty, we piloted the knowledge test on PGY-1 residents and faculty in primary care, respiratory, and infectious disease who did not participate in the study. The same test with varied question order was utilized for maintaining consistency among pretest, posttest and retention test. A questionnaire utilized Yes or No form including willingness to learn the knowledge of infectious diseases, practice hand hygiene, practice wearing self-protection, and return to internship rotation was developed to assess participants' attitudes toward clinical practice.

#### Outcomes and Analysis

We compared mean scores in pretest, posttest and retention test between flipped classroom group and standard classroom group using independent-samples *t* test. We performed paired samples *t*-test for each dimension knowledge and overall outcome, comparing the change in scores from pretest to posttest, and from posttest to retention test in the same group. A  $\chi^2$  test was used to compare attitudes toward clinical practice between the two groups.

#### Ethics and consent

This study was deemed exempt by the Institutional Review Board of Shanghai University of Medicine and Health Sciences Affiliated Zhoupu Hospital. The need for individual participant consent was waived.

## Results

The response rate was 74 of 74 (100%) in all 3 knowledge tests and questionnaire. The average age of participants was 22.0 years, and 47.3% (35 of 74) were female. Neither age nor sex differed between the flipped classroom and standard classroom groups (Table 1).

Table 1  
Intern Characteristics in Flipped Classroom versus Standard Classroom

Characteristics	Flipped Classroom	Standard Classroom	$\chi^2$ or <i>t</i> Value	<i>P</i> Value <sup>a</sup>
Age(y), mean (SD)	21.92 (0.43)	22.00 (0.33)	0.902	0.370
Female sex, n (%)	18 (48.6)	17 (45.9)	0.054	0.816
<sup>a</sup> <i>P</i> values are derived using a <i>t</i> test for continuous variables and a $\chi^2$ test for categorical variables.				

#### Knowledge Acquisition and Retention

The mean total scores were 66.96, 83.00 and 71.59 respectively in pretest, posttest and retention test. The mean total scores of the 3 knowledge tests were significantly different in pairwise comparison (all *P* < .001). For participants in flipped classroom, their own mean total scores were both higher in posttest (86.22 versus 67.08; *t* = 12.310; *P* < .001) and in retention test (76.03 versus 67.08; *t* = 6.088; *P* < .001) respectively compared to those in pretest, and in posttest differed from that in retention test (86.22 versus 76.03; *t* = 20.297; *P* < .001) in the paired analysis. For participants in standard classroom, as depicted in Fig. 2, their mean total score had similar trend changes from pretest to posttest (66.84 versus 79.78; *t* = 8.245; *P* < .001) and from posttest to retention test (79.78 versus 67.16; *t* = 18.889; *P* < .001) compared to those changes in flipped classroom, but had no significantly different between their own pretest and retention test (66.84 versus 67.16; *t* = .213; *P* = .832).

Mean total score (66.84 versus 67.08;  $t = .096$ ;  $P = .924$ ; Fig. 2) and each dimension knowledge score (all  $P \geq .05$ ; Table 2) in pretest were not significantly different between the two groups. The flipped classroom group performed significantly better than the standard classroom group for both posttest and retention test for either mean total score (all  $P < .001$ ; Fig. 2) or five dimensions scores (all  $P < .05$ ; Table 2).

Table 2  
Knowledge Acquisition and Retention in Flipped Classroom versus Standard Classroom in Five Dimension of COVID-19

	Pretest		Posttest				Retention test				
	Flipped Classroom	Standard Classroom	t Value	P Value	Flipped Classroom	Standard Classroom	t Value	P Value	Flipped Classroom	Standard Classroom	t Value
	(n = 37)	(n = 37)			(n = 37)	(n = 37)			(n = 37)	(n = 37)	
Clinical manifestations, mean (SD)	13.89 (2.37) <sup>c</sup>	13.95 (2.30) <sup>d</sup>	0.1	0.921	16.81 (1.33) <sup>a</sup>	16.03 (1.66) <sup>a</sup>	2.243	0.028	15.08 (1.34) <sup>b</sup>	13.81 (1.33) <sup>b</sup>	4.091
Etiological detection methods, mean (SD)	16.03 (2.23) <sup>c</sup>	16.14 (2.14) <sup>c</sup>	0.213	0.832	18.84 (1.34) <sup>a</sup>	18.03 (1.66) <sup>a</sup>	2.311	0.024	17.16 (1.46) <sup>b</sup>	15.08 (1.67) <sup>b</sup>	5.696
Serological detection antibody titer characteristics, mean (SD)	12.59 (2.57) <sup>c</sup>	12.70 (2.58) <sup>c</sup>	0.181	0.857	15.97 (2.62) <sup>a</sup>	14.27 (1.35) <sup>a</sup>	3.517	0.001	14.51 (3.07) <sup>b</sup>	11.41 (1.14) <sup>b</sup>	5.772
Diagnostic criteria, mean (SD)	12.32 (2.25) <sup>c</sup>	12.08 (2.56) <sup>c</sup>	0.434	0.666	17.05 (2.26) <sup>a</sup>	14.84 (2.92) <sup>a</sup>	3.651	< 0.001	15.00 (2.43) <sup>b</sup>	12.86 (2.08) <sup>b</sup>	4.06
Clinical typing, mean (SD)	12.24 (1.96) <sup>c</sup>	11.97 (2.40) <sup>c</sup>	0.53	0.597	17.54 (1.12) <sup>a</sup>	16.62 (0.95) <sup>a</sup>	3.8	< 0.001	14.27 (1.54) <sup>b</sup>	14.00 (1.39) <sup>b</sup>	0.792
<sup>a</sup> Compared with pre-test in the same group, $P < 0.05$ .											
<sup>b</sup> Compared with post-test in the same group, $P < 0.05$ .											
<sup>c</sup> Compared with retention test in the same group, $P < 0.05$ .											
<sup>d</sup> Compared with retention test in the same group, $P = 0.739$ .											

#### Attitudes toward Clinical Practice

Compared with participants in standard classroom group, participants in flipped classroom group had higher willingness to learn the knowledge of infectious diseases, practice hand hygiene, practice wearing self-protection, and return to internship rotation (all  $P < .05$ ; Table 3).

Table 3  
Intern Attitudes toward Clinical Practice in Flipped Classroom versus Standard Classroom

Item	Flipped Classroom (n = 37)	Standard Classroom (n = 37)	$\chi^2$ Value	P Value
Willingness to learn the knowledge of infectious diseases, YES No. (%)	28 (65.12)	15 (34.88)	9.382	0.004
Willingness to practice hand hygiene, YES No. (%)	22 (68.75)	10 (31.25)	7.929	0.009
Willingness to practice wearing self-protection, YES No. (%)	24 (63.16)	14 (36.84)	5.409	0.036
Willingness to return to internship rotation, YES No. (%)	28 (66.67)	14 (33.33)	10.792	0.002

## Discussion

To our knowledge, this is the first report of a prospective educational research study in a rotation suspended setting comparing the effects of a blended learning approach to a traditional lecture format, with regard to knowledge change on COVID-19 and attitude toward clinical practice. We found all interns had significant improvement in knowledge acquisition and retention compared with their knowledge benchmark, both mean total score and five dimensions in the blended learning approach were higher than those in the standard group, and there was no significant different between the knowledge benchmark and retention within the standard group. This indicates that although both standard and blended learning approaches may improve the knowledge acquisition, the latter could make the interns better understand and consolidate the new disease knowledge. It might be based on better understanding of the new disease knowledge that interns in the blended learning group showed more positive practice attitude and better prepared them for clinical practice, such as showed higher willingness to learn the knowledge of infectious diseases, practice hand hygiene, practice wearing self-protection, and return to internship rotation. It is suggested that this blended learning approach could improve the learning initiative of interns in clinical practice, and thus help to indirectly improve the level of clinical practice in the future.

With the popularization and development of internet and computer technology, it is feasible and realistic to utilize this blended learning approach. In micro-learning, the content for the learners is short and intrepid, promotes them to use the fragmentation time study independently. Recently, a review explored how micro-learning can be used to increase retention in learners on mobile applications [7]. In CBL, typical cases engage learners in active learning using course concepts to solve important problems [8]. Studies have shown CBL is a teaching tool used in a variety of medical fields using human cases to impart relevance and aid in connecting theory to practice [9]. The impact of CBL can reach from simple knowledge gains to changing patient care outcomes [5]. Jhala M et al. found CBL was useful for deep learning and emphasized its role in life long medical learning [10]. In the flipping classroom, the roles of teachers and learners are exchanged, learners completing self-study before class and classroom time is used for interactive learning and problem solving. Findings from a meta-analysis including six studies with only one prospective randomized study [11], suggest that flipped classroom may be associated with minimal gains in student knowledge compared to lecture [12]. There are several practical problems associated with flipped classroom, particularly prominent of which is more faculty time, faculty development, or resources to ensure to be effectively delivered [13, 14, 15]. We finished the video recording in the lecture preparation stage, and according to the knowledge units decomposed into micro-lesson videos. Generally, clinical teachers collect typical clinical cases conveniently and have the ability to guide classroom discussions on clinical cases. Therefore, we did not spend more faculty time, including teacher development and preparing learning resources in our study. In other words, this blended learning approach might be utilized at minimal cost.

The interns' clinical experience was insufficient and the bedside learning could not carry on during the rotation suspended period, so traditional lecture was inevitably difficult to achieve the ideal effect. The original intention of our study was to provide a feasible way for clinical teachers to teach interns learning new clinical knowledge effectively during a special period. A flipped classroom based on micro-learning combined with CBL might form a resultant force in our study, promoting the effect of COVID-19 knowledge acquisition and retention.

This study has limitations. It was a single center study, and was assessed only in final-year undergraduate interns with high concerned topic, which limits generalizability. As a blended learning approach, our research results do not delineate whether main effect of this approach derived from flipped classroom, micro-learning or CBL. Additionally, both control and observation formats and all evaluations in our study were entirely online, which needs network communication and technology support.

Further research should investigate whether the positive effect can be replicated in other medicine curriculums including offline or online combined offline lectures on a broader scale and explore whether the main effect comes from flipped classroom, micro-learning or CBL by detailed cohorts study and preference survey.

## Conclusion

A flipped classroom based on micro-learning combined with CBL showed greater effectiveness in COVID-19 knowledge acquisition and retention without sacrificing more faculty time or development, and made the attitude toward clinical practice more positive in final-year undergraduate interns. This blended learning approach could be recommended to use as a strategy to learn knowledge of new diseases under a rotation suspended situation.

## Abbreviations

COVID-19: Coronavirus Disease 2019; CBL: case-based learning; WHO: World Health Organization; WFME: World Federation for Medical Education; BME: Basic Medical Education; PPT: PowerPoint

## Declarations

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Acknowledgments

The authors would like to thank additional members of the Teaching and Training Department of Shanghai University of Medicine and Health Sciences Affiliated Zhoupu Hospital who supported this project, especially Junwei Zhu, Xin Jan, Dongjie Tian and Jiawen Yao.

Funding

This work was funded by the Teaching Research Program sponsored by the Academic Office at Shanghai University of Medicine and Health Sciences.

Authors' contributions

The article is co-first authored by QQ and JZ. Both worked jointly on this project from the very beginning and have completed the intellectual and other work typical of the first author. QQ designed and conceptualized the study and obtained funding for the study. QQ and JZ wrote the first draft of the manuscript. All authors (QQ, JZ, FX, FZ) were involved in data acquisition, analysis and interpretation of results, and critically reviewed and edited the manuscript. All authors (QQ, JZ, FX, FZ) read and approved the final manuscript.

Corresponding author

Correspondence to Qiaohui Qian.

Ethics declarations

Ethics approval and consent to participate

This study was deemed exempt by the Institutional Review Board of Shanghai University of Medicine and Health Sciences Affiliated Zhoupu Hospital. The need for individual participant consent was waived.

Consent for publication

Not applicable.

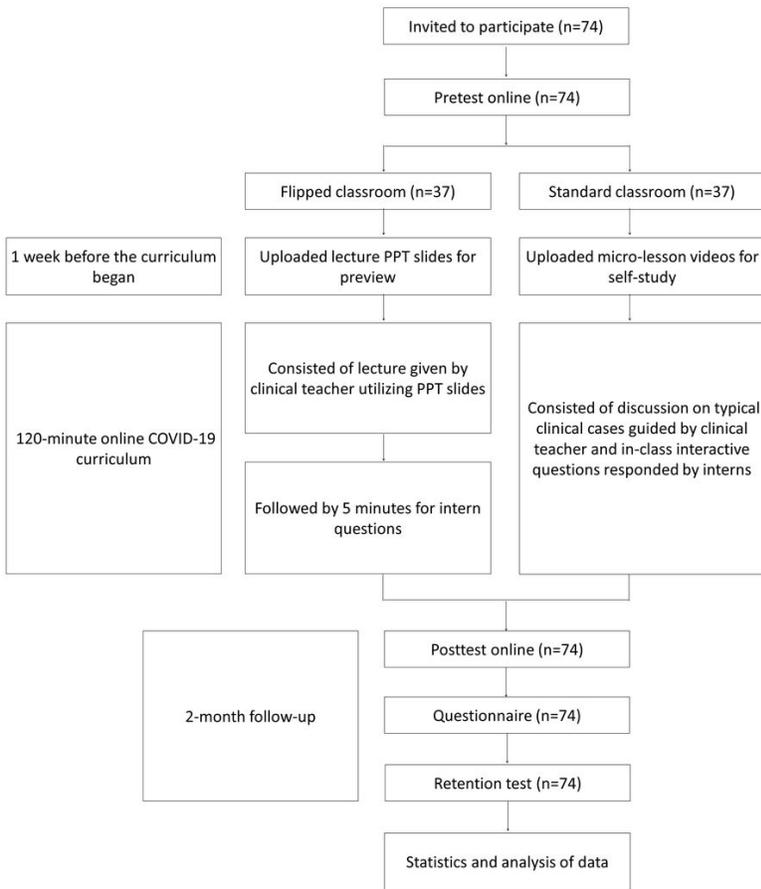
Competing interests

All authors have nothing to disclose.

## References

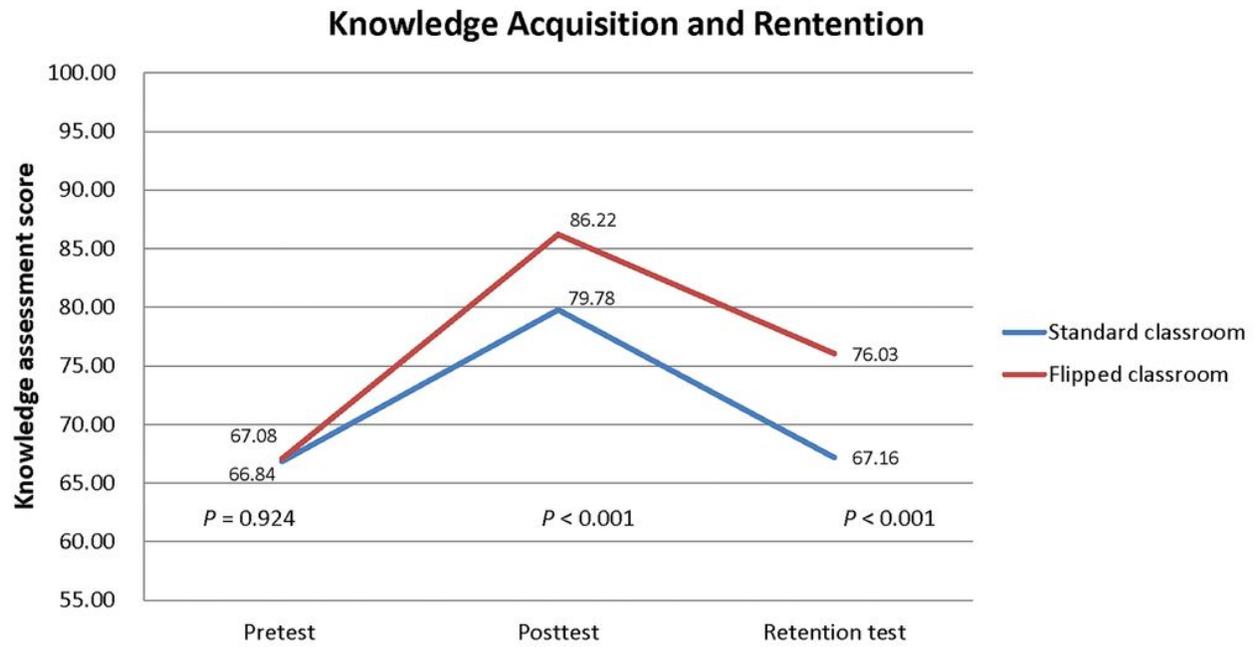
1. Li Q, Guan X, Wu P, et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia. *N Engl J Med*. 2020;382(13):1199–207.
2. Karle H. Global standards and accreditation in medical education: a view from the WFME. *Acad Med*. 2006;81(12 Suppl):43–8.
3. Hew KF, Lo CK. Flipped classroom improves student learning in health professions education: a meta-analysis. *BMC Med Educ*. 2018;18(1):38.
4. Isba R. When I say ... micro learning environment. *Med Educ*. 2015;49(9):859–60.
5. McLean SF. Case-Based Learning and its Application in Medical and Health-Care Fields: A Review of Worldwide Literature. *J Med Educ Curric Dev*. 2016;3:JMECD.S20377..
6. Office of National Health Committee, Office of National Administration of Traditional Chinese Medicine. Diagnosis and Treatment of COVID-19 (trial 7th edition). 2000. <http://www.nhc.gov.cn/yzygj/s7653p/202003/46c9294a7dfe4cef80dc7f5912eb1989/files/ce3e6945832a438eaae415350a8ce964.pdf>. Accessed 10 March 2000.
7. Shail MS. Using Micro-learning on Mobile Applications to Increase Knowledge Retention and Work Performance: A Review of Literature. *Cureus*. 2019;11(8):e5307.
8. Crowe S, Cresswell K, Robertson A, et al. The case study approach. *BMC Med Res Methodol*. 2011;11:100.
9. Greenberg-Worisek AJ, Campbell KA, Klee EW, et al. Case-Based Learning in Translational Biomedical Research Education: Providing Realistic and Adaptive Skills for Early-Career Scientists. *Acad Med*. 2019;94(2):213–6.
10. Jhala M, Mathur J. The association between deep learning approach and case based learning. *BMC Med Educ*. 2019;19(1):106. Published 2019 Apr 11.
11. Anderson HG Jr, Frazier L, Anderson SL, et al. Comparison of Pharmaceutical Calculations Learning Outcomes Achieved Within a Traditional Lecture or Flipped Classroom Andragogy. *Am J Pharm Educ*. 2017;81(4):70.
12. Gillette C, Rudolph M, Kimble C, et al. A Meta-Analysis of Outcomes Comparing Flipped Classroom and Lecture. *Am J Pharm Educ*. 2018;82(5):6898.
13. McLaughlin JE, Roth MT, Glatt DM, et al. The flipped classroom: a course redesign to foster learning and engagement in a health professions school. *Acad Med*. 2014;89:236–43.
14. Koo CL, Demps EL, Farris C, et al. Impact of flipped classroom design on student performance and perceptions in a pharmacotherapy course. *Am J Pharm Educ*. 2016;80(2):Article 33.
15. Graham KL, Cohen A, Reynolds EE, et al. Effect of a Flipped Classroom on Knowledge Acquisition and Retention in an Internal Medicine Residency Program. *J Grad Med Educ*. 2019;11(1):92–7.

## Figures



**Figure 1**

Research Design and Interventions Abbreviations: PPT, PowerPoint Note: Both flipped classroom and standard classroom utilized the Network Teaching Platform built and provided by Shanghai University of Medicine and Health Sciences to carry out 120-minute online COVID-19 curriculum. All 74 interns (100%) responded pretest, posttest and retention test, and completed the questionnaire online.



**Figure 2**  
 Knowledge Acquisition and Retention in Standard classroom versus Flipped Classroom for Overall Outcome a aGroup mean total scores on knowledge assessment test at baseline (pretest), immediately after the online COVID-19 curriculum (posttest), and 2 months later (retention test). The change in scores between baseline and immediately after the curriculum represents knowledge acquisition and is significantly better using a flipped classroom. The change in scores from immediately after the intervention until end of 2-month follow-up represents knowledge retention and is significantly better using a flipped classroom.