

# Flipped Classroom Combined With Case-based Learning Is an Effective Teaching Modality in Nephrology Clerkship

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## Research Article

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# Abstract

## Background

Both flipped classroom (FC) and case-based learning (CBL) are recognized as new effective teaching approaches by emphasizing on different aspects of teaching activities; however, the implementation of FC combined with CBL has not been well explored in nephrology education. The present study aims to investigate the efficacy of FC combined with CBL in teaching nephrology via comparing with the traditional lecture-based teaching (LBT).

## Methods

Sixty-two medical clerkship students at Zhejiang University School of Medicine were equally allocated into either LBT or FC group demographically matched. The glomerular diseases module was chosen for the teaching content. Students from the FC group were required to study the pre-class materials in annotated PPT format before the face-to face discussion on the relevant cases during the class. Students from the LBT group attended a didactic lecture during the class. Quiz and questionnaires were performed to assess the efficacy of FC.

## Results

Participants from the FC group performed better than those from the LBT group in the quiz with higher scores in the case analysis-related questions. FC was also considered more helpful than LBT in improving high order cognitive abilities in the survey. Meanwhile, more participants agreed increased in-class pressure in FC than in LBT.

## Conclusions

This study shows the positive impact of FC combined with CBL approach on nephrology education and provides an alternative pre-class and in-class format for the FC implementation.

# Background

Chronic kidney disease is a globally major health care problem with the prevalence growing, especially in the elder population, and causes an increased demand for nephrologists[1,2]. Despite an apparent demand, interest in nephrology as a career choice has decreased as shown from the published data that have documented a decline in the number of medical graduates pursuing nephrology fellowships. Nephrology is widely viewed as a more highly specialized field focusing on rare and severe diseases as compared to other medical branches and not treated as a preferable choice [3,4] Teaching nephrology is also a demanding, complex and often frustrating task. Evidence have shown endeavors in teaching could enhance learning and interest in nephrology [5,6]. However, innovation and research in nephrology education are lacking and the literature of best teaching practices pertinent to nephrology education is very scarce [7].

Flipped classroom (FP), which represents an ongoing paradigmatic shift in education from teacher-centered passive instructional strategies to student-centered active learning strategies, is growing in popularity in medical education [8-12]. FP reverses the traditional educational framework of lecture-based teaching (LBT), where the students are given faculty-provided instructional content to review outside the classroom and take part in active learning under faculty guidance based on their preparatory work in the classroom with the goal of facilitating higher order learning of the material. Literature has reported that FP has been incorporated into several various health sciences education including pharmacology, radiology, emergency medicine, dermatology, physiology and other subjects in the past decades [11-15]. FC approach has also been extended to the medical clerkship and pre-vocational training with encouraging outcomes [16-20]. Studies have demonstrated that the use of FC improves board scores, increase resident satisfaction and enhance the self-perceived competence of the material [21,22]. However, the implementation of FC in nephrology education has not been well explored. The aim of this study was to evaluate the students' learning outcomes and enjoyment of the pedagogies between traditional LBT and FP in nephrology clerkship.

## Methods

### Participants

A total of 62 fourth-year medical students majoring in clinical medicine at Zhejiang University School of Medicine were enrolled at the Second Affiliated Hospital of Zhejiang University School of Medicine. They had attended all the nephrology lessons provided in by the same instructors. These participants were allocated into either FC (n = 31) group or LBT (n = 31) group with gender matched (Table 1). The research was approved by the Institutional Review Board and Ethics Committee of the Second Affiliated Hospital of Zhejiang University School of Medicine.

**Table 1. Demographic information of participants in the study.**

| <b>Number of participants (percentage)</b> |                  |                   |
|--|------------------|-------------------|
|  | <b>FC (n=31)</b> | <b>LBT (n=31)</b> |
| <b>Gender</b>                              |                  |                   |
| Male                                       | 19 (61.29%)      | 21 (67.74%)       |
| Female                                     | 12 (38.71%)      | 10 (32.26%)       |

FC: flipped classroom group; LBT: lecture-based teaching group

### Study design

We chose the module of glomerular diseases to apply the teaching approaches in this study for two reasons. First, the glomerular diseases are among the leading causes of end stage renal diseases, which

is one of the most important modules in nephrology teaching. Second, they share similar symptoms and signs but possess differential pathogenesis and pathological patterns, which is complicated and energy-consuming for students to understand and master.

The study was carried out following the flowchart as demonstrated in Figure 1. Briefly, FC proceeded as follows: participants were provided with instructor-generated lecture notes in annotated PPT format and required to view the materials on his/her own time one week before the class. The class session started with a brief introduction of the topic, learning objectives and class agenda by the instructor. An active learning format is utilized where students encountered the real clinical cases and were challenged to take turns interpreting and discussing the cases which are representative of the glomerular diseases covered in the preassigned reading materials. The attending nephrologist provided guidance and feedback as the students interpreted the representative cases, pointing out characteristic and atypical findings for each case as well as providing clinical correlation. Finally, the instructor made the summary for the class and went over the tough questions raised by students during discussions. LBT run as follows: participants were encouraged to preview the related textbook or reference materials prior to the class and then attended a didactic lecture followed by a question-and-answer session which was aligned with the same learning objectives as those in FC group.

### **Data evaluation and statistical analysis**

To evaluate the learning outcomes, students were required to complete a post-class quiz related with the glomerular diseases when they had finished the study of this module. All items in the quiz were A2-type questions aiming to evaluate both basic theoretical knowledge and clinical case analysis ability based on the Bloom's Taxonomy of cognitive activities with "remember" and "understand" categories collapsed into "basic theoretical knowledge" and items in any of the other categories considered "clinical case analysis" [23,24]. The scores were calculated and compared between the two groups by an independent samples *t*-test.

The participants from both groups were also required to complete a questionnaire with questions on their perception of and experience with the teaching models (items covering both positive and negative aspects) as well as their self-evaluations using a three-point Likert-type scale (-1, disagree; 0, neutral; 1, agree). The questionnaire was modified from Paul Ramsden's Course Experience Questionnaire and Biggs' Study Process questionnaire with verified reliability and validity [25-27].

All methods were carried out in accordance with relevant guidelines and regulations.

## **Results**

### **Students' performance in the post-class quiz**

A total of 62 students were enrolled in the study, including 31 students assigned to the FC group and 31 students assigned to the LBT group. The gender for the two groups are matched (Table 1.). The class

attendance rates of both groups were 100%. The efficacy of teaching modalities on the students' performance were assessed by the post-class quiz which was conducted when the study of the glomerular disease module was finished. The data showed that students in FC group had higher average scores than those in LBT group ( $78.06 \pm 2.515$  vs.  $65.16 \pm 3.209$ , 95% CI: 4.748 to 21.06,  $p=0.0024$ ). Further analysis revealed that there was no difference in scores related with basic theoretical knowledge between the two groups ( $42.26 \pm 1.518$  vs.  $37.74 \pm 2.006$ , 95% CI: -0.5152 to 9.54,  $p=0.0776$ ), while higher score regarding with the clinical analysis ability was observed in the FC group than the traditional LBT group ( $35.81 \pm 1.657$  vs.  $27.42 \pm 1.910$ , 95% CI: 3.328 to 13.45,  $p=0.0016$ ) (Figure 2). These findings suggested that both LBT and FC were suitable for the delivery of basic theoretical knowledge, but in case of training for the higher level of cognitive abilities, FC presented greater advantages than LBT.

### **Students' self-perceived competence and satisfaction survey**

Next, students' self-perceived competence was compared after taking the FC and LBT classes respectively. The response rates for the questionnaire of both groups were 100%. As shown in Figure 3, more students agreed that the FC could help improve their abilities of comprehension ( $p=0.0245$ ), critical thinking ( $p=0.0014$ ) and patient management ( $p=0.0007$ ) compared with the LBT, while there was no difference in learning fundamental knowledge ( $p=0.0765$ ) between two groups. This was consistent with the students' performance in the quiz where students from the FC group performed better in high order cognitive abilities than those from the LBT group. Meanwhile, more students agreed that the FC could benefit their teamwork ( $p=0.0117$ ). These positive perspectives produced a higher rate of satisfaction with FC than LBT ( $p=0.0142$ ). In contrast, more in-class pressure was considered by students from the FC group than LBT group ( $p=0.0054$ ). Although pre-class study is the critical component for FC, there was no significant difference in the students' opinion about the pre-class workload ( $p=0.1835$ ) (Figure 3).

## **Discussion**

The interest in nephrology fades and the need for nephrology care and insights into the functioning of the kidney grows make us a must to prepare our medical students to practice quality clinical care and undertake research to understand renal physiology and pathophysiology in future [1-4]. Effective and enthusiastic teaching in medical school and residency is a first step in this direction [5-7]. In the present study, we implemented FC in clerkship students and compared the students' perspectives and performance with those experienced LBT teaching modality, which was a novel attempt and provided insights for teaching of other modules in nephrology.

We demonstrated that FC was more effective in terms of culturing high levels of cognitive abilities compared with LBT. This effectiveness of FC may be attributed to several aspects during the preparation and implementation of the course [9,10]. In the pre-class session, FC provides self-paced pre-class learning and students can use their time more efficiently. During the class, FC emphasizes on the high levels of cognitive abilities by encouraging students to utilize what they have learned to solve the more complex problems. This output process is involved in not only the knowledge and comprehension but

also the ability of application, analysis and synthesis. Thus, FC offers a sequential and gradual learning process which bridges the gap between pre-class learning of foundational knowledge and in-class training of application and problem-solving abilities [9,10]. Consistent with previous studies in other subjects, our findings have also demonstrated that the FC approach improves students' learning performance in nephrology clerkship [12,13,18,20]. Meanwhile, students in the FC group felt more confident in their teamwork than those in the LBT group. These findings should be particularly encouraging to educators to consider applying the FC model to other nephrology modules since it is evidently effective in improving the wide-spectrum cognitive abilities of students.

Interestingly, although participants in FC group performed better as a whole, some of them gave negative feedback about the in-class pressure. This negative feedback might be partly attributed to the learner's reluctance to change when a new teaching modality is introduced. The FC model is characterized by the student-centered, active learning, which can be challenging to students who are accustomed to the passive learning in medical school. The requirement of active involvement in the in-class presentation and discussion was considered an extra burden by these students. The burden and pressure may thus compromise the satisfaction with the course. Therefore, a few points should be taken into account when FC is considered to be implemented [28,29]. First, start FC with a clear definition of learning objectives and ensure that all activities are aligned to achieve the desired objectives by providing the framework for the pre-class workload and straightforward learning objectives during the class. Second, optimize the pre-class workload that is suitable for students using the FC approach. There is no conclusive suggestion yet from previous literature on what the pre-class workload should be. Future studies may be warranted in order to optimize the time dedicated to the flipped classroom approach. Third, create a friendly and comfortable atmosphere in the class which is critical to encourage students to express themselves during learning process.

There is a limitation in this study. We did not extend the study to the after-class work but just focused on pre-class and in-class activities, while after-class activities help in reinforcing and optimizing the prior learning with ongoing practice. Complexity, spacing, and time constraints are critical factors influencing the implementation of after-class work, which can be achieved in a structured way through additional programs.

## Conclusions

In summary, FC combined with CBL represents an effective and flexible approach in medicine education and can be tailored to meet the various education situations. Further studies with elaborated design to optimize FC in terms of specific subjects, student's workload, optimal strategies and the evaluation system could help further advance the impact and effectiveness of FC.

## Abbreviations

FC: flipped classroom; LBT: lecture-based teaching.

# Declarations

## Acknowledgement

Not applicable.

## Authors contributions

F Yang designed the study, conducted the teaching activities and drafted the manuscript; W Lin coordinated with the students, facilitated with the teaching activities and analyzed the questionnaire and the post-class quiz. Y Wang edited and revised the manuscript. All authors contributed to the critical revision of the paper and approved the final manuscript for publication.

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## Availability of data and materials

The related materials including the teaching materials, forms, quiz and questionnaire are kept in hard and/or soft copies in the Department of Nephrology Zhejiang University School of Medicine Second Affiliated Hospital. The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

## Ethics approval

This study was waived for the ethics approval by the Institutional Review board and Ethics Committee of the Second Affiliated Hospital of Zhejiang University School of Medicine. The informed consent was obtained from all subjects as students have participated in the study.

## Consent to publish

Not applicable.

## Competing interests

The authors report no declarations of interest.

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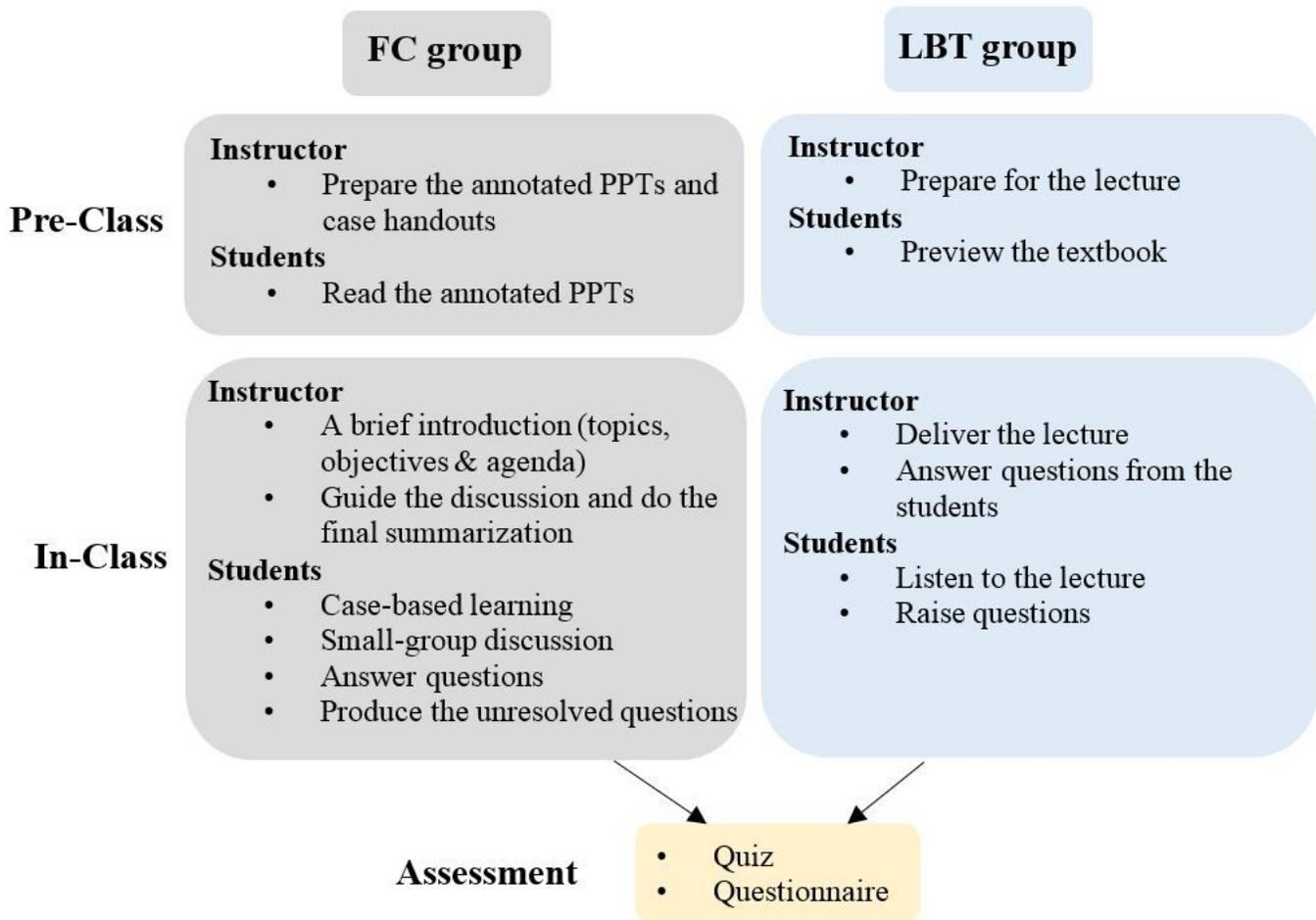
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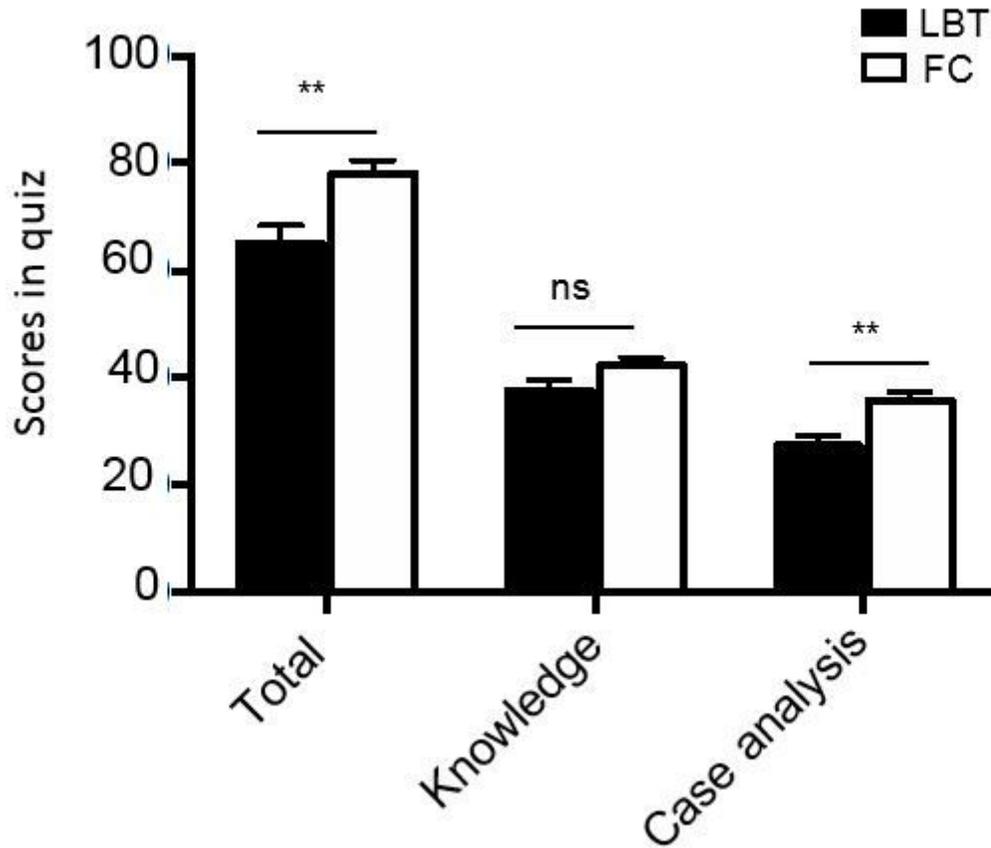
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## Figures



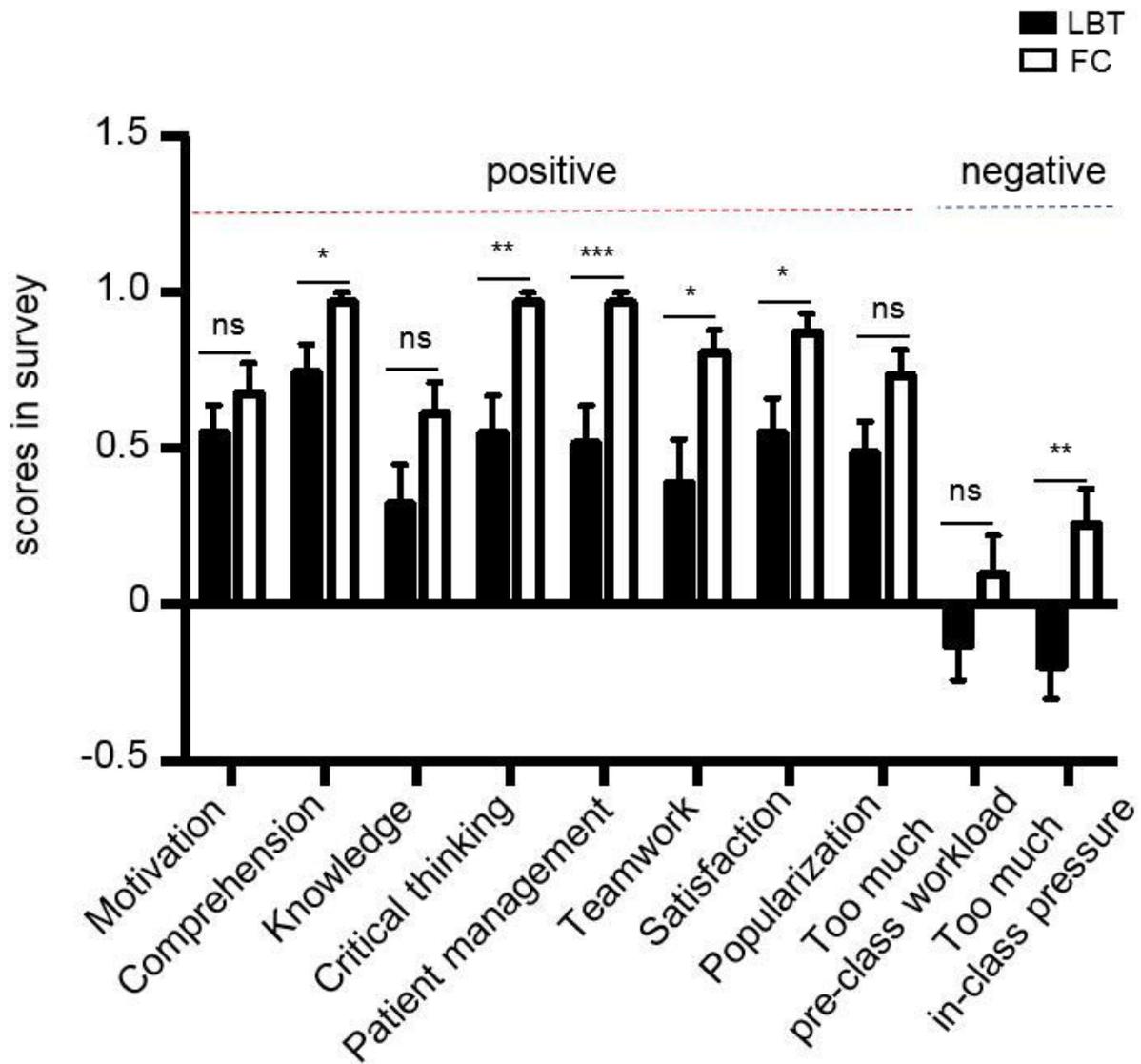
**Figure 1**

Schematic demonstration of the process of teaching activities. In LBL model, students are exposed to new materials in class through lecture delivered by the instructor. In contrast, students in FC model are first exposed to the material prior to class through faculty-generated resources (annotated PPT files) and involved in active case-based learning during the class. LBT, traditional lecture-based teaching; FC, flipped classroom.



**Figure 2**

Comparison of students' quiz scores between the FC group and LBT group after the classroom. Total, knowledge-related and case analysis-related questions were scored respectively. An independent samples t-test was used to compare the differences between the two groups. Data were presented as mean  $\pm$  SEM. In total questions,  $t=3.165$  ( $df=60$ ),  $**p=0.0024$ ; in knowledge-related questions,  $t=1.795$  ( $df=60$ ),  $p=0.0776$ ; in case analysis-related questions,  $t=3.316$  ( $df=60$ ),  $**p=0.0016$ . NS: not significant. LBT, traditional lecture-based teaching; FC, flipped classroom.



**Figure 3**

Comparison of students' self-perceived competence and perspectives on the teaching modality experienced between the FC group and LBL group. Students' answers to the survey questions were quantified using a three-point Likert scale (-1, disagree; 0, neutral; 1, agree). Data presented indicate the mean scores±SEM. \* $p < 0.05$ , \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .