

Technology-Enhanced Active Learning with Flipped Classroom on Otolaryngology Education

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Objective: To determine the learning outcomes in otolaryngology education, comparing the traditional lecture-based classroom with the flipped classroom combined with a case-based approach.

Materials and Methods: The participants were fourth year medical students and divided into two groups, the traditional classroom group and the flipped classroom group. The topic “vertigo” was chosen for the content of the present study. The traditional groups were assigned to attend a didactic lecture. The flipped group were assigned to watch the video lecture and answer the quizzes on the online application “Edpuzzle”, and they used time during the in-class activity for case-based discussion and role playing involving the doctor-patient interaction. All participants completed a questionnaire, and the final assessment scores.

Results: Two hundred thirty-nine medical students were enrolled. Some 113 students participated in the traditional group, and 126 students participated in the flipped group. The knowledge assessment in the flipped group had significantly higher scores than those from the traditional group ($p=0.042$ and <0.001 respectively). Objective structured clinical examination scores and the score of some items in the questionnaires were also significantly higher in the flipped group than in the traditional group ($p<0.001$).

Conclusion: The implementation of the flipped classroom consists of pre-class activities using an instructor-developed video and a free online application, combined with a case-based approach during the in-class activity appears to be more effective in terms of medical students gaining knowledge and skills on otolaryngology education compared with the traditional instruction method.

Keywords: Flipped classroom; Otolaryngology; Vertigo; Technology; Active learning

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The goal of medical education is to produce well-trained physicians to have excellent clinical skills, provide quality patient-centered care, perform care responsibly, embrace life-long learning, and capably demonstrate interpersonal and communication skills⁽¹⁾. Of the many new medical pedagogical approaches introduced to enhance active learning and increase medical students’ competency, the flipped classroom instructional approach has gained popularity in medical education^(2,3). A flipped classroom, or inverting the classroom, is a pedagogical strategy that delivers course materials outside the classroom as

preparation for in-class activity. Pre-class assignments allow for self-paced learning, self-directed learning, and self-regulated learning⁽⁴⁾. In-class time is dedicated to interactive activity, problem solving, and discussing the topic with their peers. Several studies have reported increased student learning and a positive perception of the flipped classroom in health professions education^(2,5).

Recent advancements in information communication technology, such as internet access and mobile communication devices such as smartphones, tablet, and laptop computers, have transformed the learning style of new generations of medical students⁽⁶⁾. Online digital education has been adopted and is gaining popularity in health professions education⁽⁷⁾. Online digital education is seamlessly compatible with the pre-class activity of flipped classrooms, in which course materials are conveniently delivered to medical students and they independently access their content anywhere and at any time^(7,8). Edpuzzle is one of the free online applications that allows instructors to create an online classroom, embed self-assessment questions, and monitor the attention of the medical student. For the in-class activity, a case-based

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approach might be suitable to blended learning, which combines medical students' theoretical knowledge and clinical practice skills. This approach can help instructors maximize the potential of the in-class activity.

The flipped classroom method has been employed in several clinical skill teaching environments, such as endocrinology⁽⁶⁾, ophthalmology⁽⁹⁾, surgery⁽¹⁰⁾, and radiology⁽¹¹⁾. However, the effectiveness of flipped courses in teaching otolaryngology has not yet been investigated. Training in clinical otolaryngology is necessary for all medical students, because approximately 10% to 50% of patients seeing a general physician have an otolaryngologic complaint^(12,13); however, the otolaryngology course comprises only a small proportion of the undergraduate medical curriculum, with limited teaching hours that have insufficient exposure to otolaryngology training⁽¹⁴⁾. "Vertigo" is one of the topics that appears to be troublesome for the otolaryngology instructor to convey to medical students, given that the various potential causes of vertigo, some of which can be life-threatening, exist among a larger group of milder conditions. The course material for vertigo is very memorization-heavy and can be overwhelming to the point that it can reduce the interest of students in the traditional classroom. Integrated information from background knowledge, precise medical history taking, and the interpretation of numerous bedside examinations are required to provide appropriate management of vertigo and to be able to recognize the need to refer the patient to a specialist. For these reasons, otolaryngology instructors must develop better pedagogical approaches to transmitting complex information to medical students in a more efficient manner.

To the authors' knowledge, few studies on the flipped classroom have been published in the otolaryngology education. The purpose of the present study was to determine the effectiveness of the flipped classroom on medical student learning outcomes on the topic of vertigo. Vertigo is one of the most difficult otolaryngology subjects, and the authors compared using online pre-class activities and a case-based approach during in-class activity with the traditional lecture-based classroom.

Materials and Methods

The present study was a retrospective and comparative study that included 239 medical students, performed at the Department of Otolaryngology, Faculty of Medicine, Prince of Songkla University,

Hat Yai, Thailand, between May 2018 and December 2019. The participants were fourth year undergraduate medical students. The participants were divided into two groups, the traditional lecture-based classroom group (n=113), which was conducted between May 2018 and December 2018, and the flipped classroom with case-based learning group (n=126), which was conducted between May 2019 and December 2019. Approximately six groups of medical students per year attended the otolaryngology program, with 18 to 21 students per group. Each group attended the classroom on the topic of vertigo once. The present study was approved by the Institutional Review Board of Prince of Songkla University (REC 63-155-13-1).

Study design

The authors used the topic of vertigo for the present study because the pathophysiology, clinical signs, symptoms, and physical examination in this topic are necessary and complicated for medical students. All the students were taught by the same one instructor. In the traditional lecture-based classroom group, the medical students were assigned to learn via the web-based module or E-learning, which contents included basic knowledge, history taking, physical examination, differential diagnosis, lab interpretation, and the common vestibular disorders before class, and they then attended an 80-minute lecture, in which the instructor gave a PowerPoint presentation followed by a 10-minute question-and-answer session (Figure 1). The flipped classroom group included a pre-class activity, in-class activity, and after-class activity. For the pre-class activity, medical students were assigned to watch a video lecture before the face-to-face class meeting. The video lecture was the same PowerPoint presentation elaborated with the instructor's live voiceover, which was uploaded online to the website www.edpuzzle.com. The video lecture was viewable on mobile devices and personal computers and was divided into five segments of 10 minutes' length. At the end of each segment, the instructor had embedded quizzes and the learner had to answer all the questions before moving on to the next segment. The learner was not able to fast forward through the video due to restrictions placed on the video to prevent skipping. The same web-based module or E-learning was also provided to the flipped classroom group.

For the in-class activity, a face-to-face class meeting was arranged for a week after the pre-class assignment date. They then attended an 80-minute in-class activity, in which the medical students were divided into four small groups with four to

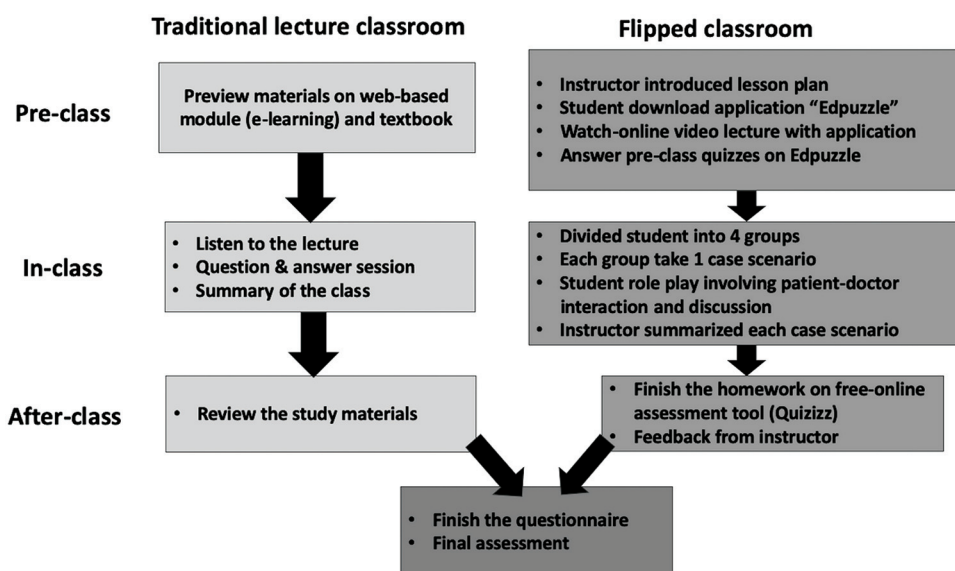


Figure 1. Flowchart illustrating the traditional lecture-based classroom and the flipped classroom models.

TG=traditional lecture-based classroom; FG=flipped classroom

five students per group. Each group was given a different case scenario with open-ended questions. A group of students first discussed the case, and then role played the patient-doctor interaction. The patient-doctor interaction included medical history taking, physical examination, investigation, diagnosis, and communication skills. The instructor assisted during class by clarifying misconceptions and guiding discussion that included fundamental knowledge, hands-on physical examination, clinical interpretation, and communication skills. Afterward, the instructor summarized the case and presented a brief lecture of five minutes in length at the end of each case scenario to provide a conclusion, clarify concepts, and give feedback. After class, the students were assigned to answer the post-test questions using a free online assessment tool application, Quizizz (a 10-minute question-and-answer session) (Figure 1).

Both groups used a similar course topic and similar assessment instruments. At the end of the otolaryngology module, the medical students underwent an assessment. The assessments included 1) knowledge assessment and clinical diagnosis via multiple-choice questions (MCQs) and organization of knowledge and problem-solving assessment via modified essay questions (MEQs), 2) clinical practice skills assessment including history taking skills and neurotology examination skills by using an objective structured clinical examination (OSCE) on a standardized patient, and 3) attitude and

perception assessment via a survey questionnaire. The questionnaire was a standard form consisting of a four-point Likert type scale as excellent=4, good=3, fair=2, and poor=1. The questionnaire items included assessments on 1) student-instructor interaction, 2) collaboration ability, 3) appropriate educational resources, 4) activity promoting clinical application and integration, 5) takes too much time to learn, 6) assessment method, 7) instructor's presentation and expression ability, and 8) learning motivation.

Statistical analysis

R statistical software (version 3.6.2, Foundation for Statistical Computing, Vienna, Austria) was used for the statistical analyses of the data. Statistical significance was considered when p-value was less than 0.05. The continuous data were calculated as medians and means with standard deviations. Categorical variables were calculated as percentages. For questionnaire results showing in Likert score data, means and standard deviations were calculated and then compared using Pearson's chi-squared test.

Results

Two hundred thirty-nine medical students were enrolled. All were in their fourth year of medical school. Of these students, 113 participated in the traditional lecture classroom group and 126 participated in the flipped classroom group. The demographic data of the participants were calculated.

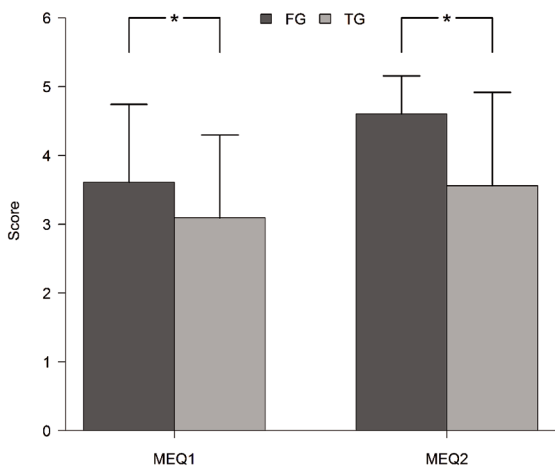


Figure 2. Comparison of the multiple essay questions (MEQ) between the flipped classroom group (FG) and the traditional lecture-based classroom group (TG).

* $p=0.042$ in MEQ1 and $p<0.001$ in MEQ2.

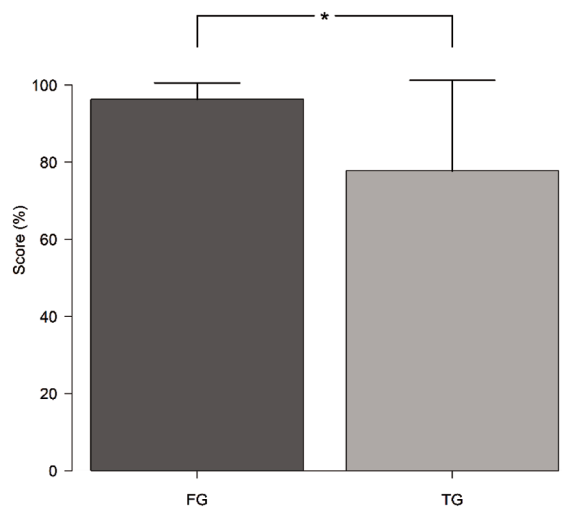


Figure 3. Comparison of the clinical practice skills assessment by using an objective structured clinical examination (OSCE) between the flipped classroom group (FG) and the traditional lecture-based classroom group (TG).

* $p<0.001$

There were no statistical differences between gender ($p=0.752$) or age ($p=0.221$).

The knowledge assessment by the two MEQ tests revealed that students in the flipped classroom group had significantly higher scores on vertigo questions than those from the traditional classroom group ($p=0.042$ and <0.001 , respectively) (Figure 2). However, the MCQ scores between the two groups were similar ($p=0.283$). OSCE scores were significantly higher in the flipped classroom group than in the traditional classroom group ($p<0.001$) (Figure 3). The postintervention score showed that there were significant differences between the traditional classroom group and the flipped classroom group in the knowledge assessment and the skill assessment.

The response rates for the questionnaires were 98.4% in the flipped classroom group and 93.8% in the traditional classroom group. The scores on some items in the questionnaires were higher in the flipped classroom group than the traditional classroom group, including enhancing student-instructor interaction ($p<0.001$), promoting teamwork ability ($p<0.001$), providing appropriate learning resources ($p<0.001$), promoting clinical application and integration ($p<0.001$), and improvement of learning motivation ($p=0.012$). There was no significant difference between the traditional classroom group and the flipped classroom group about the scores on assessment method, takes too much time, and instructor's presentation, and expression ability (Table 1).

Discussion

In the present study, the otolaryngology module is for fourth year undergraduate medical students, in which a three-week course consists of multiple lecture-based lessons and hospital-based learning. Hospital-based learning provides practice in clinical skills and clinical experience in real-patient situations at an outpatient clinic. Previous literature had shown that the medical students found the undergraduate otolaryngology curriculum was too short for their educational needs, and they felt "underconfident" in their abilities to handle common otolaryngology complaints⁽¹⁵⁾. The teaching of vertigo is challenging because it is a complex symptom that is part of the neurotologic system. Neurology-related topics are well known among medical professionals for being especially difficult and more abstract⁽¹⁶⁾. A clinical diagnosis of vertigo can usually be achieved by taking a medical history, with reliance on the neurotologic examination. The problems of vertigo lecture-based teaching include loss of student concentration on this complex subject and difficulty performing the neurotologic examination. These may be the cause of lower MEQ and OSCE score in the traditional classroom group. It is also challenging to disseminate knowledge about vertigo with limited teaching time. Consequently, medical students have the least confidence in handling real vertigo cases. The main suggestion for solving this issue was to make changes in pedagogical strategy, with a greater

Table 1. Comparison of students' perspective between the traditional lecture-based group and the flipped classroom group

| Item | Group | Excellent (%) | Good (%) | Fair (%) | Poor (%) | p-value* |
|---|-------|---------------|----------|----------|----------|----------|
| Student-instructor interaction | TG | 76.23 | 23.77 | 0.00 | 0.00 | <0.001 |
| | FG | 98.39 | 1.61 | 0.00 | 0.00 | |
| Teamwork ability | TG | 54.34 | 45.66 | 0.00 | 0.00 | <0.001 |
| | FG | 95.97 | 4.03 | 0.00 | 0.00 | |
| Appropriate educational resources | TG | 73.4 | 26.6 | 0.00 | 0.00 | <0.001 |
| | FG | 92.74 | 5.64 | 1.61 | 0.00 | |
| Activity promoting clinical application and integration | TG | 72.45 | 27.55 | 0.00 | 0.00 | <0.001 |
| | FG | 95.97 | 4.03 | 0.00 | 0.00 | |
| Takes too much time to learn | TG | 92.45 | 7.55 | 0.00 | 0.00 | 1 |
| | FG | 92.74 | 7.26 | 0.00 | 0.00 | |
| Assessment method | TG | 94.34 | 5.66 | 0.00 | 0.00 | 0.421 |
| | FG | 97.58 | 2.42 | 0.00 | 0.00 | |
| Instructor's presentation and expression ability | TG | 90.4 | 9.6 | 0.00 | 0.00 | 0.287 |
| | FG | 95.28 | 4.72 | 0.00 | 0.00 | |
| Learning motivation | TG | 90.28 | 9.72 | 0.00 | 0.00 | 0.012 |
| | FG | 99.19 | 0.81 | 0.00 | 0.00 | |

TG=traditional lecture-based classroom group; FG=flipped classroom group.

* The two groups were compared using Pearson's chi-squared test with Yates' continuity correction.

integration of fundamental neurotology concepts and clinical practice skills⁽¹⁶⁾. One of strategies that enables medical students to transform learning from theory into clinical practice, is the “flipped classroom”. The flipped classroom is a pedagogical strategy that inverts traditional lecture-based teaching by delivering course materials outside the classroom, known as “pre-class activity”, and moves interactive activity into the classroom, known as “in-class activity”, allowing students to build their knowledge and make clinically relevant diagnoses. The flipped course also does not disturb the regular timetable; thus, it can overcome some of the time constraints on the undergraduate otolaryngology curriculum.

The online pre-class activity gives students the opportunity to learn fundamental concepts at their own pace and take advantage of a personalized learning environment, instead of relying on the instructor's pace as occurs in the traditional classroom group. The design of pre-class activity must consider student preferences, the student time required to finish an activity, and how to maintain students' attention. Among the numerous pre-class educational resources for self-study such as textbooks, free online resources, paid online course materials, or lecture materials, most of the students still relied on lecture materials or handouts that emphasized the requirement for

guidance by the instructor⁽¹⁷⁾. The lecture materials should be transformed to formats that help to teach the core concept in an effective manner. One of the formats that has been approved for pre-class learning is the instructor-developed videos⁽⁴⁾. The video lecture should be divided into multiple segments, and each segment should be 20 to 30 minutes in length to allow the student to fully concentrate on the materials⁽¹⁸⁾. The visual and audio quality of the video lecture should be excellent to facilitate student learning. Moreover, pre-class materials should be provided on a student-friendly and easily accessed platform. Using technology for support can ensure that the medical students who attend the in-class activity are well prepared and ready to participate in the blended learning in-class activity. Edpuzzle is a free online application that can be downloaded onto any mobile device or personal computer. Instructors upload their contents, create their own online classroom, embed the quizzes, and monitor the engagement of the medical student in real time. The benefits of the Edpuzzle platform include 1) tracking how students learn through an instructional video such as how long that they watch the video, which parts are repeated or rewound, and when they watch the video, 2) the application prevents video skipping but the student is able to pause or replay the video as often as needed to better understand core concepts, 3) the application

allows the instructors to monitor the results of the quizzes in real time, and 4) the learning pattern demonstrated during the pre-class activity allows an instructor to recognize a student's misinterpretation or misunderstanding of concepts that can help in better planning the in-class activity⁽¹⁸⁾. A flipped course using this application does not only transfer traditional lectures outside of the class but is also important to ensure that the pre-class activity and in-class activity are harmonious⁽¹⁹⁾. The barriers to using an online application that could affect pre-class activities include the time needed, a possible lack of technical skills, insufficient infrastructure, and a negative attitude towards this approach⁽²⁰⁾.

The aim of the in-class activity was to apply knowledge, critical thinking, higher order thinking, and interpersonal and communication skills to a specific topic. A case-based approach is suitable for in-class activity because it is an effective way to encourage active learning that requires the student to participate in class, work together with their peers, and apply the pre-class learning material to solve realistic clinical case⁽³⁾. Some studies have suggested that abstract subject material like neurology is not suitable for a flipped classroom^(21,22). Moreover, this teaching method has not been shown to be beneficial for examination performance⁽⁵⁾. In contrast, the authors were able to demonstrate higher scores on the knowledge and skill assessments in the flipped classroom group. The flipped groups performed better on the clinical interpretation and neurotology skills examination, indicating that pre-class knowledge combined with a case-based approach and hands-on physical examination during role-play at the in-class session promotes better student performance. Case-based learning provides an experience of real clinical practice that helps students improve clinical thinking skills and problem-solving ability⁽²³⁾. Furthermore, the role-play setting can provide student the opportunity to practice what they will confront in a real clinical situation. There are also other benefits such as the students obtain immediate feedback and direction from the instructor on their activity in real time, and small group activities allow all participants in the group to participate and build their collaboration skills. Consequently, the combination of online pre-class activity and in-class interactive activity by using a case-based approach can facilitate a deep understanding of theoretical knowledge and strengthen clinical practice skills⁽¹⁰⁾. This teaching modality also offers ways to increase otolaryngology exposure without placing an additional burden on the

regular medical education curriculum⁽¹⁴⁾. However, there are some limitations to the flipped classroom. First, medical students must spend a lot of additional time preparing the pre-class activity. It can be overwhelming and burdensome for students who focus more on passive knowledge for examinations, given the present study questionnaire revealed no difference in the satisfaction of assessment methods between the two teaching modalities. Second, the clinical instructor with time constraints must spend extra time preparing an active classroom and updating the latest information technologies compatible with the new generation of medical students. Finally, the present study demonstrated only an improvement in short-term outcomes, however, long-term knowledge retention from this teaching modality should be further investigated.

Conclusion

The implementation of the flipped classroom consisting of pre-class activity, using an instructor-developed video with a free online application, combined with a case-based approach during the in-class activity, is a more effective teaching modality in terms of improving medical student knowledge and skills in otolaryngology education compared with the traditional instruction method. Moreover, medical students have reported being satisfied with the flipped course.

What is already known on this topic?

A flipped classroom is a pedagogical strategy that delivers course materials outside the classroom as preparation for in-class activity. This teaching modality is satisfying in several clinical skill teaching environments, such as endocrinology, ophthalmology, surgery, and radiology.

What this study adds?

The implementation of the flipped classroom consisting of pre-class activity using an instructor-developed video with a free online application, combined with the in-class activity, is effective teaching modality of otolaryngology education in terms of improving medical student knowledge and skills.

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Conflicts of interest

The authors declare no conflict of interest.

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