The efficacy of peer teaching for medical microbiology lectures [version 2]

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Abstract
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Background: A thorough understanding of infectious diseases is needed by medical professionals; therefore effective microbiological teaching is critical. Although faculty lectures are a convenient means of educating large groups of students, they may fail to engage students and convey an understanding of the subject. Therefore, we developed peer teaching methods based on game-based learning using a reality musical talent show format.

Methods: A group of student representatives were trained to lecture to a class of 300 third-year medical students via a game show format over a 3-year period (2013–2015).

Results: The students reported a higher level of understanding (3.6–4.2 vs 3.6–3.9 out of 5; \( p \))

Conclusions: Peer teaching did improve the students' attitude towards learning and conferred teaching skills, but the learning activity needs adjustment to reduce the out-of-class preparation time.

Keywords
Microbiology, Communication skills, Undergraduate, Collaborative/peer-to-peer, Lectures/large group

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Any reports and responses or comments on the article can be found at the end of the article.
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Introduction
Understanding the complex interactions between the host and microbes is vital among medical professionals. However, in medical school, most teaching focuses on the host with comparatively little time allocated to microbiology teaching. For example, only 6.5 credits are allocated for microbiology, whereas 71.5 credits are allocated for host subjects (such as anatomy, physiology, and biochemistry) in the preclinical part of our curriculum. Thus, effective microbiology education in the limited time available is critical.

Although small group teaching is ideal, it is not practical when dealing with large groups of students as it would require more staff and space than may be available. By contrast, large group teaching by faculty lectures typically results in limited attention levels and short-term memory of the subject area among the audience, leading to a lower level of understanding of the subject being taught, indicating that it is not an optimal method for skill teaching (Grauer et al. 2008, Persky and Pollack 2010, Wood 2003).

Peer teaching, also referred to as peer-assisted learning or near-peer teaching, is defined as ‘an educational arrangement in which one student teaches one or more fellow students’ (Bene and Bergus 2014). Although a recent meta-analysis showed no significance difference in the outcomes between students taught by faculties and those taught by their peers (Rees et al. 2016), peer teaching does still offer many benefits to students’ learning. For example, peer teaching helps to prepare physicians for their future role as educators, to train leadership skills and confidence, to create a comfortable and safe educational environment, to practice peer feedback as part of their multi-source feedback, and to enhance intrinsic motivation in students (Bene and Bergus 2014).

Despite the great benefits of peer teaching, it is often practiced unsystematically and informally without staff involvement. This may lead to deviations from standard teaching practices and study outcomes. Moreover, effective-learner students disproportionately gain more knowledge when it is left to chance (Rees, Quinn, Davies and Fotheringham 2016). Therefore, formalised peer learning under faculties’ supervision can help students to learn more effectively and consistently.

In recent years, gaming approaches have increasingly been used in education (Drace 2013, Masonjones et al. 2014, Pettit et al. 2015). In general, games are designed for players to achieve feedback using a reward-based approach, to engage via social interactions through an online platform, and to feel less threatening as the games lack any real-life negative impact (Boeker et al. 2013). Therefore, several studies have attempted to use game-based learning and all showed greatly enhanced engagement of students (Drace 2013). The benefits of incorporating games into learning activities include improved social skills, a more comfortable learning environment, and enhanced recall of factual knowledge (Pitt et al. 2015). However, since game-based learning is informal, supplementation with formal learning by faculties is also necessary to ensure that the required level and appropriate type of knowledge is being achieved by students (Pitt, Borman-Shoap and Eppich 2015).

A variety of peer-teaching methods have been effectively implemented. These methods range from one-to-one teaching to one teacher to a large group of students (Rees, Quinn, Davies and Fotheringham 2016, Sailer et al. 2010, Secomb 2008). Generally, several core concepts of learning are incorporated into peer-teaching methods. First, activities are generally based on ‘problem-solving’ to motivate students for discussions and eventually develop their ‘critical-thinking’ skills. Second, the topic for discussion must be relevant to their current interests and the activities must be designed to mandate every student to participate to ensure ‘engagement’ of the students. Third, activities are typically run by students sharing ideas with the group; this allows students to learn from the ‘feedback’ of their peers. Finally, these activities are best coordinated under supervision and involve feedback from faculties to ensure ‘learning outcomes’ are met.

Thus, we moved from faculty lectures into peer teaching to improve an efficacy of the learning activities and implemented a game-based approach. We found that lectures given by well-trained peers resulted in a more positive attitude towards microbiology learning among students, with similar knowledge outcomes to those taught by faculties.

Methods
Activity design for peer teaching
In Thailand, a medical student had to complete 6-year medical curriculum to get a degree of doctor of medicine. In our medical school, the 2nd and 3rd year, a pre-clinical year, was focused on basic medical sciences of normality and abnormality of human bodies, respectively. No simulated patient was used in the pre-clinical year. The students practiced with the “real” patients in 4th-6th year, a clinical year. Therefore, a medical microbiology course, which was a basic knowledge for infectious diseases, was placed in the 3rd year. However, without clinical experience, to have students engaged in basic medical science is challenging. Therefore, upon approval by our institutional ethics committee
We incorporated game-based peer teaching into our microbiology classes replacing selected topics previously taught by faculties. To ensure, the medical microbiology course covered all mandated learning outcomes for Thai preclinical year, the course learning outcome was determined according to a medical competency assessment criteria for national license 2012 (available from https://www.tmc.or.th/file_08062012.pdf). Generally, in the 3rd year of our medical school, teachings were done either in a large class of 330 students or small class of 25-30 students. A structure of the microbiology classes is presented in Figure 1. Our study was focused on the large class in the basic microbiology part in which basic principles of microbiology was taught (Figure 1). Teachings in the infectious diseases part were delivered simultaneously with other disciplines, including pathology, parasitology, clinical pathology, pharmacology, and relevant specialties from the clinical year, and was further separated into system blocks, including cardiovascular system, nervous system, respiratory system, kidney-urinary-bladder system, skin and musculoskeletal system, gastrointestinal and biliary system, endocrine and multi-organ system, and hematopoietic system. Peer teaching was performed with third year medical students in the Faculty of Medicine at Siriraj Hospital Mahidol University (Bangkok, Thailand) from years 2013 to 2015 (a class of 330 students) replacing faculty lectures taught in 2012. To maximise the attention and engagement of students, the activity design was generally based on a popular Thai reality musical talent show, called Academy Fantasia which was a franchise of the La Academia from Mexico. The reality show was run as followed: 1) 12-24 contestants were selected to live together in a isolated house, spending their days taking classes in singing, dancing, acting, and related fields. 2) each preparing one or two songs for a weekly 3-hour concert broadcasting for TV viewers and a live studio audience. 3) Each week, one of the contestants was removed based on the number of votes by telephone or online each one receives until the winner was decided. To imitate the show, a representative student was selected by their fellow students from each of the 12 small groups in the class. The small group members were arranged independently by our education department which was also used by all other courses in the 3rd year. Each representative was tasked with giving a lecture about pathogenic microbes. Different microorganisms were randomly assigned to each representative. The steps involved in the peer-teaching activity are shown in Table 1.

Evaluation of the efficacy of peer teaching

- **Attitude towards peer teaching:** Two parameters were evaluated: understanding the taught-topic and overall impression. These parameters were evaluated by a Likert-scale questionnaire using a rating scale of 1 to 5, where: 1 = very little, 2 = little, 3 = fairly good, 4 = good, 5 = excellent. The question "To what extent did the activity contribute to (parameter of interest)?" was posed by the questionnaire. The scores for topics taught by peer teaching were compared with those taught by faculties (see also Figure 1).

- **Teaching skills:** The teaching skills of the peer teachers were evaluated according to the teaching scores given by the faculties in small-group teaching sessions later in the year. Students were asked to divide into small groups of five students. Each group of students was assigned to give a mini-lecture on infectious disease to a class of 50 students five times. Every student in the group had to participate in the teaching during each session. Teaching scores for each session for each student were evaluated by rating on a 1 (very bad) to 10 (excellent) scale based on the quality of the content and the presentation. The mean scores for the groups with peer teachers were compared with those of the groups without peer teachers (see also Figure 1).

![Figure 1. Structure of the microbiology classes and parameters for comparison in this study](image-url)
**Time commitment:** Out-of-class time, which was spent by faculties for peer teaching and faculty teaching, were compared. The number of hours of preparation and participation in the teaching were calculated (see also Figure 1).

**Knowledge outcome:** Knowledge outcomes were determined by the scores from summative evaluations at the end of a semester using multiple choice questions (MCQ). MCQs in the basic microbiology part were mostly consisted of recalled questions asking about basic characteristics of pathogenic microbes. MCQs in the infectious diseases part were mostly consisted of case-based questions asking about diagnostic and therapeutic approaches for infectious diseases. As the summative scores for the same topics needed to be compared, comparison of the summative scores for the same year with peer teaching was not possible. Splitting of the class into peer-taught and faculty-taught groups was also not possible as our ethics committee advised against such a measure. Therefore, we compared the mean summative scores of the same topics to those of the year 2012, for which the subject ‘pathogenic microbes’ was taught by faculties only. To minimise bias caused by differences in the quality of students each year, the summative test scores were normalised by dividing the scores for the subject ‘pathogenic microbes’ by those for ‘general concepts’ (see also Figure 1).

### Statistical analysis
Statistical analysis was performed using the Mann–Whitney U test or the Student t-test by PSAW program version 18. Statistical significance was designated as p

### Results/Analysis
#### Activities
In the year 2013, a representative for each of the 12 groups within the class of 330 medical students was trained to teach a topic based on pathogenic bacteria for a total of 4 hours (2, 1 and 1 hour for the first, second and third rounds,

| Steps of activities | Benefits | Learning theories |
|---------------------|----------|------------------|
| 1. Twelve medical students volunteered as representatives from each section of a class of 330 students to give lectures in selected topics to the whole class | - To create safe and comfortable education environment as students feel they own the class | - Peer teaching |
| 2. These volunteered medical students were subjected to be carefully trained and supervised for both microbiological knowledge and presentation skills by faculties. At least 2 training sessions were done prior to each peer lecture. | - To prepare the peer teachers for their future role as educators<br>- To ensure correct content delivery to the class | - Peer teaching |
| 3. All training sessions were broadcasted by Facebook and the contestants were promoted by their section peers using YouTube to post their extra-presentations of the taught subjects. Other students can leave comments for the practice. | - To practice peer feedback as part of multi-source feedback for the peer teachers<br>- To train leadership skills and confidence for the peer teachers | - Peer teaching |
| 4. Facilitated by faculties, the class teaching was done interactively and mainly by students. At least 2 multiple-choices-question (MCQ) formative evaluations right after each topic using electronic voters. | - To maximize teaching efficacy as facilitation was not part of the training<br>- To practice peer feedback as part of multi-source feedback for the peer teachers | - Peer-teaching<br>- Game-based |
| 5. The activity was run as a competition which consisted of 3 rounds, qualifying (12-14 students), semi-final (6-7 students) and final rounds (3 students). Selections for winners of each round were done by scoring based on their performance from both medical-educator judges and popular votes from all students. The top three winners and their small group peers had their rewards as special scores in the microbiology subject and small amount of money. | - To create safe and comfortable education environment as students feel they own the class<br>- To practice peer feedback as part of multi-source feedback for the peer teachers<br>- To enhance engagement of students | - Peer-teaching<br>- Game-based |
respectively). In the years 2013 and 2014, topics based on pathogenic fungi and viruses were included in the teaching to a total of 5.25 hours (2, 1.25 and 1 hour for the first, second and third rounds, respectively).

Students felt that peer teaching gave them a better understanding of the taught subjects and were more satisfied with peer teaching than faculty teaching.

Typically, peer teaching creates a positive learning environment that encourages student engagement. We therefore evaluated if such positive feelings were experienced by our students. Using a simple Likert-scale questionnaire, peer teaching was found to result in significantly higher understanding and satisfaction scores, as shown in Table 2.

**Peer teachers’ teaching skills were enhanced**
As peer teaching is thought to help prepare physicians for their future role as educators, we evaluated if peer teachers developed better teaching skills. We evaluated the teaching skills of the peer teachers by determining their teaching performance at a subsequent peer teaching activity later in the year. The teaching scores of the groups of peer teachers were compared with groups containing no peer teachers. As expected, the groups containing peer teachers had significantly higher teaching scores than groups without peer teachers (Table 3). As all peer teachers generally were selected from top students of each small group, knowledge outcome achievement of those peer teachers could not be fairly compared with other students.

**Peer teaching was more time-consuming than faculty teaching**
Since peer-teaching activities included training sessions for the peer teachers, the preparation time was expected to be more than that for faculty teaching. Therefore, the out-of-class time taken for teaching preparation was compared, and the results indicated that it took more out-of-class-time for faculties to prepare for peer teaching than that required for faculty lectures (44 versus 16 hours for 2013, 49 versus 19 hours for 2014 and 2015).

**Similar knowledge outcome to faculty teaching was achieved by peer teaching**
According to previous meta-analysis, faculty lectures resulted in similar knowledge outcomes to peer teaching. We therefore compared the outcomes of peer teaching to faculty teaching based on the summative evaluation scores. The scores for subjects taught by peer teachers were comparable to those of subjects taught by faculties (Table 4).

**Discussion**
Peer teaching is being increasingly used in a number of medical schools globally (Gusic et al. 2013). As the demand for physicians is steadily increasing, the availability of qualified medical educators to teach the next generation of medical

### Table 2. Mean scores (out of 5) for each evaluated item on the questionnaire

| Year | Type            | Understanding the subject | p-value | Overall satisfaction | p-value |
|------|-----------------|---------------------------|---------|----------------------|---------|
| 2013 | Peer-teaching   | 3.60                      | 0.965   | 3.89                 | < 0.001 |
|      | Faculty-teaching| 3.63                      |         | 3.62                 |         |
| 2014 | Peer-teaching   | 3.88                      | < 0.001 | 4.03                 | < 0.001 |
|      | Faculty-teaching| 3.64                      |         | 3.62                 |         |
| 2015 | Peer-teaching   | 4.24                      | < 0.001 | 4.28                 | < 0.001 |
|      | Faculty-teaching| 3.85                      |         | 3.79                 |         |

### Table 3. Comparison of teaching scores

| Year | Type                  | Presentation scores (10) | p-value |
|------|-----------------------|--------------------------|---------|
| 2013 | Groups with peer-teachers | 8.90                    | < 0.001 |
|      | Groups without peer-teachers | 8.42                    |         |
| 2014 | Groups with peer-teachers | 9.24                    | < 0.001 |
|      | Groups without peer-teachers | 8.68                    |         |
| 2015 | Groups with peer-teachers | 9.11                    | < 0.001 |
|      | Groups without peer-teachers | 8.67                    |         |
students is limited, potentially reducing the quality of student learning. Peer teaching seems to be a valuable tool with which to tackle this problem. However, as the quality of teaching provided by students may be variable, teacher training is mandatory. With proper training, peer teaching has been accepted to be equal to faculty teaching. Therefore, we implemented such measures in the teaching of our microbiology course and the results were promising. The students reported high levels of satisfaction as they felt they could understand the microbiological subjects better after peer teaching than after lectures provided by the faculty. As knowledge outcomes gained by peer teaching was equivalent to those obtained by faculty teaching, peer teaching was considered a promising learning method for our large class size of more than 300 students.

The positive attitude towards peer teaching reported in our study was in line with previous reports (Mills et al. 2014, Rashid et al. 2011). One previous study reported a positive influence on learning by the implementation of peer learning (Rashid, Sobowale and Gore 2011). Another study stated a high level of satisfaction towards peer teaching (Mills, Dalleywater and Tischler 2014). In our study, overall satisfaction was reported to be higher as a result of peer teaching than for faculty teaching. This might be due to the fact that students felt they could understand the microbiological subject better. Such positive feelings towards peer teaching might be due to the more comfortable learning environment that results from having their peers as teachers. The comfortable learning environment created by peer teaching has been well documented in a number of previous studies (Secomb 2008).

One concern regarding peer teaching lies within the quality of delivery of the content, which directly influences the knowledge outcome of the students. Therefore, we included several training sessions for the representatives targeting both their understanding of the subject matter and their presentation skills. The resulting data for peer teaching showed equivalent knowledge outcomes among the students to faculty teaching. This was consistent with the results of a recent meta-analysis of peer teaching that revealed that peer teaching provided similar knowledge outcomes to faculty teaching (Rees, Quinn, Davies and Fotheringham 2016).

An additional benefit of peer teaching is that it prepares physicians for their future role as educators (Kensinger et al. 2015). In Thailand, as in many other countries, medical doctors play an important role as leaders and representatives of the medical profession among communities in rural areas. Typically, Thai medical practitioners are tasked with educating their communities in terms of basic public health knowledge (Crombie et al. 2005). Therefore, teaching skills are critical for Thai medical doctors but, to date, such training was not officially included in our medical curriculum as a mandatory course. In response, we propose that peer teaching may enhance the teaching skills of our students. We found that peer teachers performed better in teaching sessions later in the year. Moreover, other students in the same teaching groups also displayed improved teaching skills. This suggested that peer teaching did not only increase the teaching skills of the peer teachers themselves but also had a positive effect to those students who interacted with the peer teachers. All peer teachers reported that they trained their fellow students in the teaching skills learnt from our peer teaching activities (data not shown). Taken together, our findings indicate that peer teaching is a promising tool to enhance the teaching skills of future medical doctors in Thailand.

**Conclusion**

The study provides evidence that peer teaching can be effectively implemented for medical microbiology education. Benefits included high satisfaction levels among students and enhanced teaching skills, without compromising knowledge outcomes. However, a major concern by staff was the fact that the time taken to prepare for such activities was approximately twice as high as that was required for faculty teaching. Therefore, fine adjustments to the activities involved in our peer teaching are warranted to reduce the preparation time before full-scale implementation can take effect.

**Take Home Messages**

- Well-organised peer teaching improves attitudes towards medical microbiology teaching

| Year | Mean Score ratio* | Mean Score ratio of 2012** | p-value |
|------|-------------------|---------------------------|---------|
| 2013 | 1.22              | 1.25                      | 0.755   |
| 2014 | 1.11              | 1.12                      | 0.313   |
| 2015 | 1.17              | 1.12                      | 0.349   |

*Scores for topics taught by peer teachers/topics taught by faculty lectures.
**Year without peer teaching, 2012.
• Training peer teachers for content and presentation skills is crucial for effective large-group lectures as check points for knowledge understanding by reflection and feedback can be limited

• The learning activity for peer teaching has to be designed carefully to ensure that the preparation time is acceptable

Notes On Contributors
Popchai Ngamskulrungroj, MD. PhD., Assistant professor and a quality manager of microbiology laboratory at Departments of Microbiology, Faculty of Medicine Siriraj Hospital, Mahidol University. Popchai was a committee member of 12 preclinical subjects. He is responsible for medical mycology teaching.

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Declarations
The author has declared that there are no conflicts of interest.

Ethics Statement
This study was approved by Siriraj Hospital Ethics Committee (132/2557(Exempt)).

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Trevor Gibbs
AMEE

This review has been migrated. The reviewer awarded 4 stars out of 5

I too would like to congratulate the authors on addressing the comments raised in their previous paper and certainly the paper shows greater clarity now and demonstrates the self-perceived value of peer teaching. One of my other comments from previous was to the degree of value we place upon such a low level of course evaluation. Time does not allow a more longitudinal evaluation in this paper but I hope that the authors can carry on their project and look at how this peer-teaching activity influences later-clinical-learning.

Competing Interests: No conflicts of interest were disclosed.

Reviewer Report 25 March 2019

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Richard Hays
James Cook University

This review has been migrated. The reviewer awarded 4 stars out of 5

I would like to thank the authors for addressing the comments made by reviewers on the first version of this paper. I think that the comments have been addressed satisfactorily and that this version is improved...
and worth of citation where relevant. It is noteworthy that per teaching does not appear to be a less expensive method, if done well, but rather may be best regarded as an investment in the development of future teachers.

**Competing Interests:** No conflicts of interest were disclosed.

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**Version 1**

Reviewer Report 31 July 2017

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**Julie Browne**
Cardiff University School of Medicine

This review has been migrated. The reviewer awarded 3 stars out of 5

I enjoyed reading this paper, and congratulate the authors on their work in producing an apparently feasible and pragmatic solution to increasing students' active participation in learning and teaching in an environment where small group work is a logistical challenge. There were some areas on which I would have liked further information: First, I am not familiar with the game show format and I couldn't tell from the description how the course was arranged so that all students covered all parts of the syllabus. I would have liked more information about the overall curriculum at this medical school and how this initiative supported the wider educational aims of the institution. How did the student teachers perform in the summative assessments compared with the rest of the cohort? Did the teaching exercise benefit them and if so how? Similar exam scores were achieved by the students regardless of whether they were taught by faculty or peers. Since the peer teaching seemed very labour intensive – it required more than double the time to implement - do the authors consider that this is an intervention that should be pursued, and if so, why? Would the effort taken to train the peer teachers be better applied to developing further the teaching skills of the faculty? Do the authors have any plans to evaluate this study further? In particular, I wonder how the authors will establish that the knowledge that the students gain through the peer teaching will actually translate into good clinical practice. I hope the authors will consider building on this work in a future paper. Thank you for the opportunity to read and comment on it.

**Competing Interests:** No conflicts of interest were disclosed.
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Lakshmi Nagappa Naik  
Melaka Manipal Medical College

This review has been migrated. The reviewer awarded 3 stars out of 5

It was an interesting study especially for PAL in medical education. Regarding a subject like medical microbiology which is exhaustive and has geographical uniqueness with disease spectrum, its clinical significance needs to be emphasised. As this is an active learning method, the close supervision of the contents delivered by peers as teachers is needed. There should be an allocated time for students to be assisted by facilitators prior to presentation and at the end of session a debriefing would help. The article well highlights the elements of success for large group teaching, however the qualitative analysis in form of feedback by all participants will further strengthens the study.

Competing Interests: No conflicts of interest were disclosed.

James Read  
Plymouth University Peninsula Schools of Medicine and Dentistry

This review has been migrated. The reviewer awarded 3 stars out of 5

Thank you very much for submitting this paper to the themed edition of MedEdPublish. I read the paper with great interest and I found the format that you had chosen to deliver the peer teaching both innovative and engaging. You describe the development of the project well and the rationale for the use of such an approach is appropriately grounded in recent literature. The scores from students are clearly impressive and it is encouraging to see that they are deriving such a benefit from this approach. There are some areas that I would have liked to have seen more detail on. In particular, how you developed the topics that needed teaching and how these were prioritised over other areas. I also question how much
of the benefit is due to the peer teaching and how much is due to an innovative and memorable approach to teaching. I think this significantly confounds your results. I think there are also questions about the impact on students who do not perform as well in their peer feedback and how you have supported these students; both academically and emotionally. I also am always concerned about the use of quantitative statistics when using scales (either 1-10 or likert scales). When using statistical analyses on this data you need to bear in mind that the numbers on the scale mean different things to different people, and that the difference between the numbers may not be constant. Your \( p \) values therefore need to be viewed in this context and I would have preferred to see some more qualitative analysis of student comments etc. Overall an interesting paper. Thank you for submitting.

**Competing Interests:** No conflicts of interest were disclosed.

Reviewer Report 20 July 2017

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Trevor Gibbs

AMEE

This review has been migrated. The reviewer awarded 3 stars out of 5

Any teaching and learning activity that increases active learning seems to derive a benefit for the students and a motivational benefit for the faculty concerned- as such this paper, which increased active learning of both the recipient students and the peer student teachers, was a welcome addition to our increasing knowledge regarding peer-teaching. However it is important to recognise how much importance we place upon the findings from such an activity.-Does the time spent on such an activity outbalance the overall effectiveness of looking at the relevance of microbiology and what emphasis is placed upon the subject. I would have liked to have seen some work initially carried out on what should be taught, rather than as it appears, microbiology is taught as an independent, non integrated block that pays little attention to the relevance and appropriateness of what is taught- is this really active learning or are we just substituting peers for faculty and delivering the programme through the same lecture format?- can we make the positive conclusions given in the paper from the evaluation methodology used, can we move the evaluation further up the line to measure real effect upon learning rather than the low level used in this paper? I congratulate the authors in their attempts to improve microbiology teaching but I feel that there is still much to create in this area and would encourage the authors to keep up their enthusiasm in this area.
**Competing Interests:** No conflicts of interest were disclosed.