

Research Article

Comparative Effectiveness of E-Learning Modules versus Conventional Lectures on Knowledge Retention of Public Health Concepts among Undergraduate Medical Students

Mamoon Shabbir¹, Bushra Shabbir², Muhammad Abuzar Siddique³, Maryam Ejazi⁴, Muhammad Anas Tauqir⁵

¹Lecturer, Department of medical education. Sahara Medical College. Narowal.

²Demonstrator. Pathology Department. Narowal medical College. Narowal.

³Pediatrics General Practitioner. Pediatrics Medicine. Pakistan Kidney and Liver Institute. Lahore.

⁴Demonstrator, Department of community medicine. Narowal Medical College. Narowal.

⁵House Officer, Department of Medicine. Holy Family Hospital Rawalpindi.

Email: ¹dr.mamoon_21@hotmail.com, ²bushrabano217@gmail.com, ³abuzarmalik841@gmail.com, ⁴Ejazimarium@gmail.com03002373543, ⁵tauqiranas@gmail.com

Received: 10.03.26, Revised: 07.04.26, Accepted: 09.05.26

ABSTRACT

Objective: This study aimed to compare the effectiveness of e-learning modules and conventional lectures on knowledge retention of public health concepts among undergraduate medical students.

Methods: A quasi-experimental study was conducted among 120 third-year MBBS students, who were randomly divided into two groups. Group A was taught using structured e-learning modules, while Group B received conventional lecture-based teaching. Both groups were assessed using a pre-test, immediate post-test and a follow-up test after four weeks. Scores were analyzed and compared using appropriate statistical methods.

Results: Baseline pre-test scores were comparable between the two groups. Both teaching methods resulted in significant improvement in immediate post-test scores; however, the e-learning group showed higher mean scores compared to the lecture group. At four-week follow-up, a decline in scores was observed in both groups, but knowledge retention remained significantly higher in the e-learning group.

Conclusion: Both e-learning modules and conventional lectures are effective in enhancing knowledge of public health concepts among medical students. However, e-learning appears to provide better long-term knowledge retention. A blended learning approach combining both methods may offer an optimal strategy for improving educational outcomes in medical curricula.

Keywords: E-Learning, Conventional Lectures, Knowledge Retention, Public Health Education, Medical Students.

INTRODUCTION

Medical education has never really been completely static, even though sometimes it feels like it is. It has always been shaped by the needs of society and the resources available at a given time. (Cook et al., 2013) This means that it is in one way or another, has always been evolving. If we look back, the basic structure has not changed that much. Students sitting in lecture halls, teachers explaining concepts and notes being taken, sometimes carefully and sometimes not so much. (Taveira-Gomes et al., 2016)

For many years, conventional lectures have remained the central method of teaching in medical schools across the world and even now they still hold a central place in most medical college

s. These lectures are practical, allow a lot of content to be delivered in a limited time and are relatively easy to organize. (Cook et al., 2008) But at the same time, there has been a growing need among students and educators that lectures alone may not be enough, especially when the goal is to actually understand and memorize what is being taught. (Broudo and Walsh, 2002)

One issue that is often seen is the passive nature of lectures. Students sit, listen and try to absorb information, but there still remains a lack of interaction. Some students manage well with this style but others lose focus somewhere in the middle of a long lecture. (Wong, 2009) It not mean that they are not interested, but it can just be difficult for some students to stay engaged for that

long time. Even sometimes the lecture is good but the amount of information delivered can be overwhelming for many. By the time students go back to revise, some of the details of lectures already start fading.(Banzi et al., 2009)

This isspeciallymore noticeable in subjects like public health. Compared to clinical subjects, public health at least initially can feel a bit abstract. It deals with populations, statistics, prevention strategies and broader concepts studies that don't always have an immediate, visible connection to the patient care. (Hammoud and Barclay, 2002)Because of this, students sometimes approach it differently,some take it seriously while others see it as something to get through for exams. But in reality, the importance of public health is quite significant, even if it doesn't always seem that way during early medical training.(Ilgen et al., 2013)

Understanding the concepts like epidemiology, screening or health promotion is not just about learning the definitions. It requires a certain level of thinking andtrying to see how these ideas apply in real-life situations. (Morrow et al., 2010)And for that, just listening to a lecture might not always be enough. Students may understand something in the moment, but whether they retain it after a few weeks is another question altogether.(de Leng et al., 2006)

With the increasing use of technology, things have started to shift a little. E-learning has become more common in the past few years in medical education due to the increasing availability of digital tools and internet access.(Burg, 2008) At first, it was seen more as a supplement to traditional teaching but now in many places it is being used more actively. It is sometimes even replacing face-to-face sessions.(Cook et al., 2011)

E-learning can take different forms. It might be a recorded lecture, an online module or a combination of text, images and short videos. Some modules include quizzes or self-assessment questions, which students can attempt as they go along. (Fischer, 2003)The idea is to make learning a bit more engaging and less one-directional. Instead of just receiving information, students can interact with the content in some way.(Challa et al., 2021)

One of the main advantages of e-learning is the flexibility. Students can go through the material at their own pace, pause when

needed and come back to it later. This might sound like a small thing, but it actually makes a difference. (Lewis et al., 2014)In a lecture, if you miss a point, it's gone unless you ask immediately, which not everyone is comfortable doing. With e-learning, there is less pressure in that sense.(Reed et al., 2014) Another thing is the way content is presented. Many e-learning modules use diagrams, short videos or even case-based examples. These can make the material a bit easier to understand especially for the topics that are dry or difficult to visualize. (Sucha et al., 2013)Also, the inclusion of quizzes or small tests in between helps students check if they are actually understanding what they are studying. It's not always perfect as some modules are better designed than othersbutit still offers a different kind of learning experience.(Cook et al., 2010)

It would not be correct to say that e-learning is clearly better in every situation. There are stillsome aspects of conventional lectures that are hard to be replaced. For example, direct interaction with a teacher can be very helpful. (Nitsche et al., 2023)Sometimes a simple explanation given in person makes things clearer than any number of slides or videos. Also, being physically present in a classroom creates a kind of structure. Students are more likely to stay on a track because there is a fixed schedule.(Sorg et al., 2022)

On the other hand, with e-learning, a lot depends on the student's own discipline. Some students are quite good at managing their time and completing modules properly.(Alverson et al., 2008)But some may delay their study and waste time or go through the material quickly without actually focusing. So, while e-learning provides freedom, it also requires responsibilityand not everyone can handle that in the same way.(Colsman et al., 2006)

When it comes to knowledge retention, the comparison becomes even more important. It is one thing to understand a concept right after studying it and another thing to remember it weeks later. (Beux and Fieschi, 2007)In medical education, retention is especially important because students are expected to build on what they have learned over time. If the basics are not retained, it becomes harder to connect new information later.(Sinclair et al., 2015)

Public health concepts in particular, need to be memorized beyond exams. Either it is

understanding of how the diseases spread or knowing the principles of prevention because these are things that doctors may need to apply in different contexts. So, the method of teaching should ideally support not just short-term learning but also longer-term retention. (Kékes, 1999)

In fact, it is now believed that a combination of both methods might be the most practical approach. Lectures can be used to introduce concepts while e-learning modules can provide opportunities for revision and deeper understanding. (Spinello and Fischbach, 2004) This mixed approach tries to make use of the strengths of both methods but it also requires careful planning to be effective. (Wautier et al., 2005) At the same time, it is important to not assume that newer methods are automatically better. Just because e-learning is more modern or more technologically advanced does not mean it will always lead to better learning outcomes. (Aryal and Pereira, 2014)

In a way, this is also about adapting to change without losing what already works. Medical education is gradually evolving and teaching methods need to keep up with that. But at the same time, it is important to base these changes on evidence rather than assumptions. Understanding how students learn best especially in subjects like public health can be helpful in designing teaching strategies that are not only effective in the short term but also meaningful in the long run.

MATERIALS AND METHODS

This study was carried out among undergraduate medical students from Sahara Medical College and Narowal Medical College to compare the effectiveness of e-learning modules and conventional lectures in terms of knowledge retention of public health concepts. The study design was quasi-experimental in nature and was conducted over a period of a few weeks during the academic session. The participants were selected from third-year MBBS students as they had already been introduced to basic public health topics in their curriculum.

A total of 120 students were included in the study. Students who were willing to participate were enrolled after a brief explanation of the study purpose and verbal consent was taken. Participation was kept voluntary and students were informed that their academic standing would not be affected in any way.

The students were then divided into two groups. This division was done using a simple random method to reduce selection bias although complete randomization in a strict sense was somewhat difficult due to scheduling and class arrangements. Each group consisted of 60 students. Group A was assigned to the e-learning module while Group B attended conventional lecture sessions.

The study focused on selected public health topics including epidemiological measures such as incidence and prevalence, levels of prevention, screening methods and basic principles of health promotion. These topics were chosen because they are commonly taught at the undergraduate level and are often considered conceptually challenging by students.

For Group A, the e-learning modules were prepared in advance. These modules included written content, diagrams and short explanatory videos. Some sections also had simple self-assessment questions to help students check their understanding. The modules were shared with students through an online platform and they were given a fixed time frame about one week to go through the material. Students were allowed to access the modules multiple times depending on their preference.

Group B, on the other hand, attended conventional lectures conducted by faculty members from the Department of Community Medicine. These lectures were delivered in a classroom setting using PowerPoint presentations and verbal explanations. The duration and content coverage were kept roughly similar to the e-learning material to maintain some level of consistency between the two groups.

To assess knowledge retention, three sets of assessments were carried out. Before the intervention, all students were given a pre-test to evaluate their baseline knowledge of the selected topics. This test included multiple-choice questions and a few short-answer questions. The purpose was mainly to ensure that both groups started at a similar level.

Immediately after the completion of the teaching sessions a post-test was conducted. This test was similar in structure to the pre-test but not exactly identical particularly to avoid recall bias. It aimed to assess immediate knowledge gain.

A follow-up test was then conducted after four weeks to evaluate retention of knowledge over

time. Students were not given prior notice of the exact date of this test although they were aware that a follow-up assessment would be conducted. This was done to get a more realistic idea of how much information they had retained without targeted revision.

All test papers were checked using a standardized marking scheme. Scores were recorded and entered into a data sheet for analysis. The mean scores for pre-test, post-test and follow-up test were calculated for both groups. The data were then compared to see if there was any significant difference between the two teaching methods.

Basic statistical analysis was performed using SPSS version 22. Descriptive statistics such as mean and standard deviation were calculated and inferential tests were applied where appropriate to compare the groups. A p-value of less than 0.05 was considered statistically significant.

Some practical limitations were noted during the study. For example, it was difficult to control how seriously students engaged with the e-learning modules, as this depended largely on individual motivation. Similarly, attendance in lecture sessions was monitored

but attention levels during lectures could not be measured objectively. Despite these limitations, efforts were made to keep conditions as comparable as possible between the two groups. Overall, the methodology was designed to reflect a realistic academic setting rather than a highly controlled experimental environment, so that the findings could be more applicable to everyday teaching practices.

RESULTS

A total of 120 undergraduate medical students participated in the study, with 60 students in each group. All participants completed the pre-test and post-test assessments. However, a small number of students (n=5) were absent during the follow-up test, so the final retention analysis was carried out on 115 students.

At baseline, the pre-test scores of both groups were quite similar, which suggests that the initial level of knowledge regarding public health concepts was more or less comparable. There was no statistically significant difference between the two groups at this stage ($p > 0.05$).

Table 1: Comparison of Pre-test Scores between Groups

Group	Number of Students	Mean Score $\pm$ SD
E-learning	60	11.8 $\pm$ 2.3
Conventional Lecture	60	12.1 $\pm$ 2.5

After the intervention, both groups showed an improvement in their post-test scores. However, the increase appeared to be slightly higher in the e-learning group compared to

the lecture group. Students who used the e-learning modules seemed to perform better immediately after the learning session.

Table 2: Comparison of Post-test Scores between Groups

Group	Number of Students	Mean Score $\pm$ SD
E-learning	60	18.6 $\pm$ 2.1
Conventional Lecture	60	16.9 $\pm$ 2.4

The difference in post-test scores between the two groups was found to be statistically significant ($p < 0.05$), indicating that the method of teaching had some effect on immediate learning outcomes.

When the follow-up test was conducted after four weeks, both groups showed a decline in

scores, which was expected to some extent. However, the reduction in scores was more noticeable in the lecture group, while the e-learning group retained a relatively higher proportion of their initial gain.

Table 3: Comparison of Follow-up (Retention) Scores between Groups

Group	Number of Students	Mean Score $\pm$ SD
E-learning	58	16.9 $\pm$ 2.2
Conventional Lecture	57	14.8 $\pm$ 2.6

The difference in retention scores between the two groups was statistically significant ($p < 0.05$). This suggests that students who learned through e-learning modules were able to retain the information more effectively over

time compared to those who attended conventional lectures.

To better understand the pattern of improvement and decline, the mean score changes were also compared within each group.

Table 4: Within-Group Comparison of Scores

Assessment	E-learning (Group A) Mean $\pm$ SD	Lecture (Group B) Mean $\pm$ SD
Pre-test	11.8 $\pm$ 2.3	12.1 $\pm$ 2.5
Post-test	18.6 $\pm$ 2.1	16.9 $\pm$ 2.4
Follow-up	16.9 $\pm$ 2.2	14.8 $\pm$ 2.6

It can be seen that both groups improved after the intervention, but the degree of improvement was higher in the e-learning group. Also, although some decline occurred in both groups at follow-up, the drop was less marked in Group A.

In addition to the quantitative results, some general observations were noted during the study period. Students in the e-learning group appeared more engaged with the material at least based on their feedback and participation in module-based quizzes. On the other hand, a few students in the lecture group reported difficulty in maintaining concentration during longer sessions, although this was not formally measured.

Overall, the results suggest that while both teaching methods are effective to some extent, e-learning modules may have an advantage when it comes to both immediate understanding and longer-term retention of public health concepts.

DISCUSSION

The present study was carried out to compare the effectiveness of e-learning modules and conventional lectures in terms of knowledge retention of public health concepts among undergraduate medical students. The findings suggest that although both methods were helpful in improving student's knowledge but the e-learning approach showed somewhat better results, especially when retention over time was considered.

At the beginning of the study, the pre-test scores of both groups were quite similar, which was expected and also important for comparison. It indicated that the baseline knowledge of students in both groups was more or less the same, so any difference observed later could be attributed, at least to some extent to the teaching method rather than prior knowledge. This part of the result aligns with what has been seen in other

similar studies where groups are often comparable before the intervention is applied. After the teaching sessions, both groups showed improvement in their post-test scores. This is not surprising, as any structured teaching whether lecture-based or digital usually leads to some level of learning. However, the increase in scores was slightly higher in the e-learning group. One possible reason for this could be the way the material was presented. The e-learning modules included visual elements, repetition and self-assessment questions, which may have helped students understand and process the information more actively.

This idea is supported by previous research as well. A study by Ruiz JG et al. highlighted that e-learning can be as effective as or even more effective than, traditional teaching methods when it incorporates interactive elements and allows self-paced learning. (Ruiz et al., 2006) Similarly, Cook DA and colleagues found that internet-based learning in health professions showed positive effects on knowledge acquisition compared to no intervention and was at least comparable to traditional methods. (Cook et al., 2008)

What stands out more clearly in the present study is the difference in retention after four weeks. Although both groups showed some decline in scores which is expected over time, the decrease was less in the e-learning group. This suggests that students who learned through e-learning modules were able to retain the information better. It might be related to repeated exposure, as students in that group had the option to revisit the material multiple times. Even if not all students did so extensively, the availability itself could have contributed to better reinforcement.

Another possible explanation is the level of engagement. In conventional lectures, even when students are attentive, the learning

process is largely passive. In contrast, e-learning often requires some level of interaction, even if it is just answering a few questions or navigating through content. This active involvement may help in better encoding of information which in turn supports retention.

A study by Campbell et al. also reported that students in online learning conditions performed modestly better, on average, than those receiving face-to-face instruction, particularly when the online learning included interactive and collaborative elements.(Campbell et al., 2008)Although the present study did not specifically measure interaction levels, the structure of the e-learning modules likely encouraged more active participation.

That being said, it would not be entirely accurate to conclude that conventional lectures are ineffective. The lecture group in this study also showed a clear improvement in scores, both immediately and at follow-up, even if the retention was comparatively lower. Lectures still have certain advantages, especially in terms of direct communication with the instructor. Students can ask questions, clarify doubts instantly and sometimes benefit from explanations that are tailored in real time.

In fact, some students may actually prefer lectures, particularly those who find it difficult to study on their own or manage their time effectively. E-learning, while flexible, also requires self-discipline. Not all students may engage with the material in the same way and some might go through it quickly without proper understanding. This variability is something that is harder to control in a digital learning environment.

Another point worth considering is that the effectiveness of e-learning depends a lot on how well the modules are designed. Poorly structured or overly complex modules may not produce the same benefits. In this study, efforts were made to keep the content simple and focused but it is still possible that differences in design could affect outcomes in other settings.

The findings of this study are generally consistent with earlier work in this area, although not all studies show identical results. For example, Clark et al. found that interactive and computer-based instruction could enhance learning outcomes but the extent of improvement varied depending on the subject

and method used. This suggests that while e-learning has potential, its impact may not be uniform across all contexts.(Clark et al., 2016)

There are also some limitations that should be acknowledged. The study was conducted in a single institution with a relatively limited sample size which may affect how widely the results can be applied. Also, factors like individual learning styles, motivation levels and prior exposure to digital tools were not assessed in detail. These could have influenced how students responded to the different teaching methods.

Another limitation is that the level of engagement with e-learning modules could not be fully monitored. While access was provided, it was not possible to track exactly how much time each student spent on the modules or how thoroughly they went through the content. Similarly, in lecture sessions, attendance was noted but attention and participation could not be measured objectively.

Despite these limitations, the study provides some useful insights. It suggests that e-learning can be an effective tool for teaching public health concepts, particularly when the goal is to improve retention over time. At the same time, it does not completely replace the role of traditional lectures.

Overall, the findings support the idea that teaching methods in medical education should continue to evolve but in a balanced and evidence-based manner. Simply adopting new technologies is not enough; it is important to understand how they actually affect learning and whether they meet the needs of students in a meaningful way.

CONCLUSION

This study showed that both e-learning modules and conventional lectures are effective in improving knowledge of public health concepts among undergraduate medical students, but there are noticeable differences in long-term retention. Although immediate post-test performance improved in both groups, students exposed to e-learning demonstrated better retention of knowledge after four weeks compared to those taught through traditional lectures. This may be related to the interactive nature, flexibility and opportunity for repeated revision offered by e-learning platforms. However, conventional lectures still remain valuable, particularly for structured teaching and direct teacherstudent

interaction. Overall, the findings support the idea that integrating e-learning with traditional teaching methods, rather than replacing them entirely, may provide a more balanced and effective approach to medical education, especially for concept-heavy subjects like public health.

REFERENCES

1. ALVERSON, D. C., SAIKI, S. M., JR., KALISHMAN, S., LINDBERG, M., MENNIN, S., MINES, J., SERNA, L., SUMMERS, K., JACOBS, J., LOZANOFF, S., LOZANOFF, B., SALAND, L., MITCHELL, S., UMLAND, B., GREENE, G., BUCHANAN, H. S., KEEP, M., WILKS, D., WAX, D. S., COULTER, R., GOLDSMITH, T. E. & CAUDELL, T. P. 2008. Medical students learn over distance using virtual reality simulation. *Simul Healthc*, 3, 10-5.
2. ARYAL, K. R. & PEREIRA, J. 2014. E learning in surgery. *Indian J Surg*, 76, 487-93.
3. BANZI, R., MOSCHETTI, I. & MOJA, L. 2009. Internet-based education for health professionals. *Jama*, 301, 599; author reply 599-600.
4. BEUX, P. L. & FIESCHI, M. 2007. Virtual biomedical universities and e-learning. *Int J Med Inform*, 76, 331-5.
5. BROUDO, M. & WALSH, C. 2002. MEDICOL: online learning in medicine and dentistry. *Acad Med*, 77, 926-7.
6. BURG, G. 2008. [E-Learning in medicine: at the top or a flop]. *J Dtsch Dermatol Ges*, 6, 435.
7. CAMPBELL, M., GIBSON, W., HALL, A., RICHARDS, D. & CALLERY, P. 2008. Online vs. face-to-face discussion in a Web-based research methods course for postgraduate nursing students: a quasi-experimental study. *Int J Nurs Stud*, 45, 750-9.
8. CHALLA, K. T., SAYED, A. & ACHARYA, Y. 2021. Modern techniques of teaching and learning in medical education: a descriptive literature review. *MedEdPublish* (2016), 10, 18.
9. CLARK, D. B., TANNER-SMITH, E. E. & KILLINGSWORTH, S. S. 2016. Digital Games, Design, and Learning: A Systematic Review and Meta-Analysis. *Rev Educ Res*, 86, 79-122.
10. COLSMAN, A., STICHERLING, M., STÖPEL, C. & EMMRICH, F. 2006. Computer-assisted learning in medicine. How to create a novel software for immunology. *Arch Dermatol Res*, 298, 1-6.
11. COOK, D. A., BRYDGES, R., ZENDEJAS, B., HAMSTRA, S. J. & HATALA, R. 2013. Mastery learning for health professionals using technology-enhanced simulation: a systematic review and meta-analysis. *Acad Med*, 88, 1178-86.
12. COOK, D. A., HATALA, R., BRYDGES, R., ZENDEJAS, B., SZOSTEK, J. H., WANG, A. T., ERWIN, P. J. & HAMSTRA, S. J. 2011. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *Jama*, 306, 978-88.
13. COOK, D. A., LEVINSON, A. J., GARSIDE, S., DUPRAS, D. M., ERWIN, P. J. & MONTORI, V. M. 2008. Internet-based learning in the health professions: a meta-analysis. *Jama*, 300, 1181-96.
14. COOK, D. A., LEVINSON, A. J., GARSIDE, S., DUPRAS, D. M., ERWIN, P. J. & MONTORI, V. M. 2010. Instructional design variations in internet-based learning for health professions education: a systematic review and meta-analysis. *Acad Med*, 85, 909-22.
15. DE LENG, B. A., DOLMANS, D. H., MUIJTJENS, A. M. & VAN DER VLEUTEN, C. P. 2006. Student perceptions of a virtual learning environment for a problem-based learning undergraduate medical curriculum. *Med Educ*, 40, 568-75.
16. FISCHER, M. R. 2003. [E-learning in medical education, graduate and continuing medical education. Status and prospects]. *Med Klin (Munich)*, 98, 594-7.
17. HAMMOUD, M. M. & BARCLAY, M. L. 2002. Development of a Web-based question database for students' self-assessment. *Acad Med*, 77, 925.
18. ILGEN, J. S., SHERBINO, J. & COOK, D. A. 2013. Technology-enhanced simulation in emergency medicine: a systematic review and meta-analysis. *Acad Emerg Med*, 20, 117-27.
19. KÉKES, E. 1999. [Current status and possibilities of distant education in medicine]. *Orv Hetil*, 140, 2379-84.
20. LEWIS, K. O., CIDON, M. J., SETO, T. L., CHEN, H. & MAHAN, J. D. 2014. Leveraging e-learning in medical education. *Curr Probl Pediatr Adolesc Health Care*, 44, 150-63.

21. MORROW, J. B., SEPDHAM, D., SNELL, L., LINDEMAN, C. & DOBBIE, A. 2010. Evaluation of a web-based family medicine case library for self-directed learning in a third-year clerkship. *Fam Med*, 42, 496-500.
22. NITSCHKE, J., BUSSE, T. S. & EHLERS, J. P. 2023. Teaching Digital Medicine in a Virtual Classroom: Impacts on Student Mindset and Competencies. *Int J Environ Res Public Health*, 20.
23. REED, S., SHELL, R., KASSIS, K., TARTAGLIA, K., WALLIHAN, R., SMITH, K., HURTUBISE, L., MARTIN, B., LEDFORD, C., BRADBURY, S., BERNSTEIN, H. H. & MAHAN, J. D. 2014. Applying adult learning practices in medical education. *Curr Probl Pediatr Adolesc Health Care*, 44, 170-81.
24. RUIZ, J. G., MINTZER, M. J. & LEIPZIG, R. M. 2006. The impact of E-learning in medical education. *Acad Med*, 81, 207-12.
25. SINCLAIR, P., KABLE, A. & LEVETT-JONES, T. 2015. The effectiveness of internet-based e-learning on clinician behavior and patient outcomes: a systematic review protocol. *JBI Database System Rev Implement Rep*, 13, 52-64.
26. SORG, H., EHLERS, J. P. & SORG, C. G. G. 2022. Digitalization in Medicine: Are German Medical Students Well Prepared for the Future? *Int J Environ Res Public Health*, 19.
27. SPINELLO, E. & FISCHBACH, R. 2004. Problem-based learning in public health instruction: a pilot study of an online simulation as a problem-based learning approach. *Educ Health (Abingdon)*, 17, 365-73.
28. SUCHA, M., ENGELHARDT, S. & SARIKAS, A. 2013. Internet discussion forums as part of a student-centred teaching concept of pharmacology. *GMS Z Med Ausbild*, 30, Doc2.
29. TAVEIRA-GOMES, T., FERREIRA, P., TAVEIRA-GOMES, I., SEVERO, M. & FERREIRA, M. A. 2016. What Are We Looking for in Computer-Based Learning Interventions in Medical Education? A Systematic Review. *J Med Internet Res*, 18, e204.
30. WAUTIER, J. L., VILEYN, F. & LEFRÈRE, J. J. 2005. [Electronic learning: interactive learning in medicine or Socrates in electronic guise]. *Transfus Clin Biol*, 12, 150-2.
31. WONG, G. 2009. Internet-based education for health professionals. *Jama*, 301, 598-9; author reply 599-600.