

REVIEW ARTICLE

## A Narrative Review on Technology-enhanced Learning in Undergraduate Medical Education

May Honey Ohn<sup>1\*</sup>, Chan Zhi Wei<sup>2</sup>, Bareth Ravindran<sup>3</sup>, TAMILASARI Sugumarn<sup>4</sup>, Khin Maung Ohn<sup>5</sup>, Constance Liew<sup>6</sup>, Alvin Oliver<sup>7</sup>

<sup>1</sup> Cardiology Department, University Lewisham Hospital, London, United Kingdom

<sup>2</sup> Medicine Department, Hospital Sungai Buloh, Selangor, Malaysia

<sup>3</sup> Medicine Department, Hospital Tuanku Ja'afar, Seremban, Malaysia

<sup>4</sup> Surgery Department, Universiti Malaya Medical Centre, Kuala Lumpur, Malaysia

<sup>5</sup> Orthopaedic Department, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Sabah, Malaysia

<sup>6</sup> Anaesthesiology and Intensive Care Department, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Sabah, Malaysia

<sup>7</sup> Medicine Department, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Sabah, Malaysia

\* Corresponding author's email: mayhoney.ohn@gmail.com

Received: 23 August 2021

Accepted: 28 June 2022

Published: 30 September 2022

DOI: <https://doi.org/10.51200/bjms.v16i3.3341>

**Keywords:** *blended learning, hybrid learning, medical education, narrative review, technology-enhanced learning*

### ABSTRACT

Technology-enhanced learning (TEL) in medical education is becoming increasingly popular because it reorganizes teaching and learning dynamics, incorporates various learning media for content delivery, and provides synchronous and non-synchronous interactions in group and individual learning. This article aimed to evaluate the usefulness of TEL models in undergraduate medical teaching. In our review of TEL in medical education, we posed three research questions to analyse its effectiveness in undergraduate medical education, which are: (a) What are the TEL modalities used in undergraduate medical education? (b) How does technology-enhanced blended learning impact students' engagement, knowledge gain, skills acquisition, and changes in perception and attitudes? (c) Is e-learning (Moodle) more effective than other technology-assisted online learning platforms in medical education? In the review, we have seen the evolution and development of TEL; its advantages and strength over traditional learning, especially in medical education, have been reiterated. As the various modalities undergo further research and develop more sophisticatedly, TEL learning would play a bigger role as mainstream later to replace the full traditional learning. Thus, educators, institutions and policymakers must be prepared and invested in the necessary financial, time and manpower resources to embrace the coming tide, to ensure successful incorporation.

## INTRODUCTION

With the advancement of web-based technologies in education, an innovative type of learning has recently drawn the attention of educators' eye. Blended learning (BL) theory includes the incorporation of traditional classroom methods with technology-enhanced learning (TEL), which involves the use of information and communications technology (ICT) (Garrison & Kanuka, 2004). The use of TEL in medical education is becoming increasingly popular because it reorganizes teaching and learning dynamics, incorporates various learning media for content delivery, and provides synchronous and non-synchronous interactions in group and individual learning. As a result, it allows medical education to be developed, scheduled and conveyed through the integration of physical and virtual instruction. There are many potential benefits in TEL compared to traditional courses. Firstly, it provides more control over students' learning and helps in fostering students' innovative and critical thinking which leads to improved achievements and levels of satisfaction as well as yields a stronger sense of community among students (Al-Qahtani & Higgins, 2013). It can be in a one-on-one or small group instructional setting. Furthermore, the content of learning is selectively customized and suited to each individual so that learners only work on relevant subjects. As a result, TEL combines the best aspects of online and instructor-directed learning.

Many TEL models essentially switch forward and backward without enabling students to make substantial connections (Brooks et al., 2016). For TEL to encourage students' engagement and deeper learning, innovative technology and practices need to complement traditional classroom instruction and vice versa. TEL used in medical schools should not only be viewed as only a teaching strategy that allows greater flexibility and creativity but as one that is far more effective

than traditional methods. Hence, this article is aimed to evaluate the different TEL models which are being used in medical teaching for undergraduate medical students. In our review of TEL in medical education, we posed three research questions to analyse its effectiveness in undergraduate medical education, which are: (a) What are the TEL modalities used in undergraduate medical education? (b) How does technology-enhanced blended learning impact students' engagement, knowledge gain, skills acquisition and changes in perception and attitudes? (c) Is e-learning (MOODLE) more effective than other technology-assisted online learning platforms in medical education?

### **RQ1: What are the TEL modalities used in undergraduate medical education?**

Web-based medical education was first reported in 1992, using 30 years of computer-assisted instruction as its foundation (Hungary & Tempus Consortium for a New Public, 1992). Computer-assisted instruction is claimed to exceed traditional educational methods and text-based lectures for various reasons such as control over the flexibility of time and place of learning (Piemme & Blumenthal, 2016), enhancement of learning, reasoning, and efficiency (Clayden & Wilson, 1988; Henry, 1990). In the beginning, blended learning (BL), a rather vague term, was used to broadly describe a variety of technologies and pedagogical methods in varying combinations. With the publication of the first Handbook of BL, the term BL became more concrete. The author challenged the ambiguity of the term's definition and defined "BL systems" as learning systems that "combine face-to-face instruction with computer-mediated instruction" (Bonk et al., 2012; Osguthorpe & Graham, 2003). In medicine, BL is commonly practised as the mixture of e-learning with student-patient-tutor experience (Duque et al., 2006), successfully infusing two archetypal learning environments with expected better end-result in terms of students' learning and

fulfilment. Some of the different modalities that are commonly used in TEL include virtual models, simulations, multimedia and electronic devices.

Virtual model or virtual reality, as suggested by its name, allows user interaction, involving five senses, through a computer-generated real-time simulated environment (Burdea & Coiffet, 1994). From the perspective of medical and healthcare education, simulation is often utilized as a technique, device or activity to teach and enhance the knowledge and skills of students by replicating and imitating real-world experiences and characteristics. Simulation is used to hone a certain set of skills which amplifies its potential as an educational tool (Nagle et al., 2009). Online resources or online learning is another commonly used modality in BL. Online learning is the result of the continuous evolution of computer-assisted instruction (Haag et al., 1999). This modality can be delivered through a variety of multimedia and electronic mediums such as laptops and mobile phones. The Web is used as a platform to deliver teachings in different formats such as texts, graphics, audio, video, animations, email, discussion boards, and testing. Online learning sessions are usually "on-demand" or self-directed, though it is not uncommon to include web-based teleconferencing (audio graphics), synchronous chats or similar technology (Gray & Tobin, 2010). There are several technical advantages of online learning, namely universal accessibility, ease of updating content, and hyperlink functions that allow cross-referencing to other resources (Haag et al., 1999).

Multimedia and electronic devices are other modalities that act as delivery media in BL and technology-enhanced learning curricula. In today's age, handheld mobile devices are the universal norm. Therefore, it is not surprising to learn of the incredible potential that these devices possess and how they can be utilised in the education sector. The term

M-Learning or Mobile Learning refers to the utilization of mobile technologies in teaching and learning (Gray & Tobin, 2010). We can infer the term "mobile technologies" in several ways, including some or all of the following gadgets: mobile phones, smartphones, such as either iOS or Android phones, personal digital assistants, netbooks, notebooks and laptops, tablet PCs, MP3 players, e-book readers such as Amazon's Kindle and Sony's e-book (Sharma & Barrett, 2010). With the advancement of the "mobile age", training and studying can be done at any time and any place. Interactive online exercises, such as quizzes, listening to podcasts or watching video podcasts are some examples of training that can be done through this technology. In some cases, the sharing of information is almost instantaneous. Certain technologies that are available in these electronic devices such as Bluetooth can be utilized by educators to transfer and share information with all students (Sharma & Barrett, 2010).

### **RQ2: How does technology-enhanced blended learning impact students' engagement, knowledge gain, skills acquisition and changes in perception and attitudes?**

Technology-enhanced, student-centred learning environments are often conducted in the problem-solving form or an orienting goal that helps to mould interrelated learning themes into meaningful contexts. This method also enables individuals to explore their unique learning interests and needs and provides an interactive medium for them to study multiple levels of complexity and deepen their understanding. Technology is utilised to enable flexible methods that are used in establishing environments that enrich thinking and learning (Hannafin & Land, 1997).

A systematic review conducted by (Ohn et al., 2020) highlighted that TEL is better than traditional learning with regards to knowledge gain and skill acquisition, as well as providing

higher student satisfaction which represents blended learning in a positive and promising light in time. A comparative study (Bock et al., 2021) indicates that blended learning in teaching local anaesthesia improves the learning outcome for theoretical knowledge more than either face-to-face learning or e-learning alone. For acquiring practical skills, blended learning is as effective as other teaching methods.

A study based on survey questionnaires uncovered that students reported the utilization of a blended mode of education, including computer-assisted learning with the use of the internet, multimedia, online lecture notes and quizzes, alongside F2F lectures, group work and practical projects, was beneficial and promoted a better quality of education (Frehywot et al., 2013). It is inferred that BL using technology is an effective medium in the current era of time to foster medical knowledge and enhance practical competencies. Another finding by (Nartker et al., 2010) inferred that BL methods provided professional development that further encourages the retention of current health workers.

Similarly, another study also showed that the majority of students enrolled in a blended drug information and literature evaluation course agreed that the use of technology such as pre-recorded videos, saves time and allowed the space for more useful face-to-face interaction and equal educational value as traditional didactic learning (Suda et al., 2014). In addition, a study by Lapidus et al. (2012) demonstrated positive student feedback in favour of a blended course in comparison to the traditional approach in a drug literature evaluation course. Mirroring the principles of adult education, BL allows for better responsiveness and greater flexibility in the teaching and learning process (Lewin et al., 2009). The incorporation of online instruction further helps to overcome the limitations of time and space and eases teachings that involve complex instructions and have

wider reach without increasing resource requirements thus making distance learning possible (Gray & Tobin, 2010). The integration of technology into pedagogy enables flexible, learner-centred teaching and leads to more positive communication between students and educators, thus facilitating better collaboration and relationships (Ellaway & Masters, 2008).

### **RQ3: Is e-learning (Moodle) more effective than other technology-assisted online learning platforms in medical education?**

Online learning or e-learning is an educational format which is driven through computer networks (Kearsley, 1999). The advent of e-learning has opened the world to distance education, allowing global education access and allowing people from the most remote areas to have access to high-quality education materials (Smaldino et al., 2004). The technological weightage of e-learning is undeniable with its universal accessibility, and ease in linking multiple sources and syncing information thus creating an interconnected maze of information (Haag et al., 1999). E-learning addresses the rigidity faced by students in terms of time and place and allows much-needed flexibility by making knowledge available at all times and places (Hannafin, 1984). This allows students to have control of their learning process in accordance with the constructivist learning theory (Chumley-Jones et al., 2002).

Often, the major plus points for online learning are increasing the availability of study materials to those who cannot access it traditionally or to students who choose not to attend traditional lectures, managing the delivery of content in a more cost-efficient manner, and/or providing opportunities for students to train under-qualified instructors who are otherwise inaccessible. Advocates of online learning further argue that this web-based learning medium will be easier and more practical to embrace due to the vast advances in current technology's support in creating an

interactive channel where social networking, collaboration and reflection can be practised to elevate the learning experience to that of a normal classroom environment (Rudestam & Schoenholtz-Read, 2003).

Despite the promising advantages of online learning, it has its share of downfalls as well. Online learning has its limitations in engaging students unless they are self-motivated active learners (Daniels & Moore, 2000) and can organize their study plans well (Oh & Lim, 2005). Furthermore, students may feel isolated and lack a sense of belonging during online learning sessions, leading to an absent communal mentality and obsolete peer relationships. In contrast, BL is propelled towards overcoming these shortcomings of online learning and creating a cohesive and wholesome education plan using various instructional approaches to enhance the student's knowledge, experiences and satisfaction. Some of the reasons why BL is preferred over online learning include improved pedagogy, increased accessibility to knowledge and ease of revision of the contents, and better interactions between students as well as with their trainers due to the personal presence and cost-effectiveness (Osguthorpe & Graham, 2003).

A study by Lim et al. (2007) revealed that student groups that were taught using both the online and BL formats respectively did not show any significant differences in the mean scores for perceived and actual learning and retention, while all students, regardless of teaching format indicated a significant increase in perceived and actual learning before and after the course. It is further elaborated in the study that students in the online learning group reported more workload and less learning support in comparison to their BL peers. This finding further echoes the importance of students' psychological state in a blended and online learning environment in which students may feel like they lack a sense of belonging in the

latter learning environment leading them to feel unsupported and burdened with a heavier workload compared to their counterparts in the BL environment. Students also feel that the BL format provides clear instruction due to the presence of a facilitator.

As one of the most widely free open-source e-learning platforms, Moodle enables the creation of a course website that ensures access only to enrolled students, utilizing various modes of knowledge dispersion, communication and student assessment processes (Costa et al., 2012). A modular object-oriented dynamic learning experiment (Moodle) was assessed in a physiology course at the University of Montenegro in 2016. Forty-nine students were recruited for the study. During practical classes, a great number of laboratory exercises were replaced by video clips and laboratory simulations, replacing 45.5% of the total practical classes. Students are still obligated to personally perform those physical examination skills. This learning model increased the interest of students, and attendance of face-to-face lectures and can improve communication among students and course instructors. It diversifies the means of student assessment and allows the instructor to give comments to the students on time and efficiently (Felder et al., 2013; Sun et al., 2008).

A study by Popovic et al. (2018) compared a group of students who attended the physiology course before, with a group of students who attended the physiology course after the Moodle platform was fully implemented as an educational tool. Formative and summative assessment scores were compared between these two groups. The impact of high vs. low Moodle use on the assessment scores was analysed. The satisfaction among Moodle users was assessed by the survey. The study found that attendance at face-to-face lectures had a positive impact on academic performance. The introduction of Moodle in the presented model of teaching increased the interest of students, attendance

of face-to-face lectures, as well as formative and summative scores. High frequency of Moodle use was not always associated with better academic performance, suggesting that the introduction of a new method of teaching was most likely equally accepted by low- and high-achieving students. Most of the students agreed that Moodle was easy to use and it complemented traditional teaching very well, but it could not completely replace traditional face-to-face lectures. The study supports continuing the use of web-based learning in a form of blended learning for physiology, as well as for other courses in medical education.

The findings were in accordance with other reports and might suggest that all students (low and high achievers) accepted the introduction of Moodle with a similar level of interest and motivation (Gazibara et al., 2015; Seluakumaran et al., 2011). It is possible that Moodle use only affects a subset of the student population in the university and the attractiveness of the module decreased with time (Antonoff et al., 2016).

## CONCLUSION

In a nutshell, as we have seen the evolution and development of TEL, its advantages and strength over traditional learning, especially in medical education, have been reiterated time and again. As the various modalities undergo further research and develop more sophisticatedly, TEL learning would play a bigger role as mainstream later to replace the full traditional learning. Thus, educators, institutions and policymakers must be prepared, and invest in the necessary financial, time and manpower resources to embrace the coming tide, to ensure successful incorporation. Researchers have an important role to play as well, as more studies should be done to compare and evaluate the strength and weaknesses of the various modalities, thus enabling adaptation and utilization of the individual modalities for maximal benefit in different settings and requirements.

## CONFLICT OF INTEREST

The authors declare that they have no competing interests in publishing this article.

## REFERENCES

- Al-Qahtani, A. A. Y., & Higgins, S. E. (2013). Effects of traditional, blended and e-learning on students' achievement in higher education. *Journal of Computer Assisted Learning*, 29 (3), 220 – 234. <https://doi.org/10.1111/j.1365-2729.2012.00490.x>
- Antonoff, M. B., Verrier, E. D., Allen, M. S., Aloia, L., Baker, C., Fann, J. I., Iannettoni, M. D., Yang, S. C., & Vaporciyan, A. A. (2016). Impact of Moodle-based online curriculum on thoracic surgery in-training examination scores. *The Annals of Thoracic Surgery*, 102 (4), 1381 –1 386. <https://doi.org/10.1016/j.athoracsur.2016.03.100>
- Bock, A., Kniha, K., Goloborodko, E., Lemos, M., Rittich, A. B., Mohlhenrich, S. C., Rafai, N., Holzle, F., & Modabber, A. (2021). Effectiveness of face-to-face, blended and e-learning in teaching the application of local anaesthesia: A randomised study. *BMC Medical Education*, 21, 137. <https://doi.org/10.1186/s12909-021-02569-z>
- Bonk, C. J., Graham, C. R., Cross, J., & Moore, M. G. (2012). The Handbook of Blended Learning: Global Perspectives, Local Designs. *Higher Education*, 624. <https://doi.org/BookReview>
- Brooks, H. L., Pontefract, S. K., Hodson, J., Blackwell, N., Hughes, E., Marriott, J. F., & Coleman, J. J. (2016). An evaluation of UK foundation trainee doctors' learning behaviours in a technology-enhanced learning environment. *BMC Medical Education*, 16 (133), 1 – 9. <https://doi.org/10.1186/s12909-016-0651-z>
- Burdea Grigore, C., & Coiffet, P. (1994). *Virtual reality technology*. Wiley-Interscience.
- Chumley-Jones, H. S., Dobbie, A., & Alford, C. L. (2002). Web-based learning: sound educational method or hype? A review of the evaluation literature. *Academic Medicine*, 77 (10 Suppl), S86 – S93. <https://doi.org/10.1097/00001888-200210001-00028>
- Clayden, G. S., & Wilson, B. (1988). Computer-assisted learning in medical education. *Medical Education*, 22 (5), 455 – 467. <https://doi.org/10.1111/j.1365-2923.1988.tb00783.x>

- Costa, C., Alvelos, H., & Teixeira, L. (2012). The use of Moodle e-learning platform: A study in a Portuguese University. *Procedia Technology*, 5, 334 – 343. <https://doi.org/10.1016/j.protcy.2012.09.037>
- Daniels, H. L., & Moore, D. M. (2000). Interaction of cognitive style and learner control in a hypermedia environment. *International Journal of Instructional Media*, 27 (4), 369. <https://link.gale.com/apps/doc/A67531178/AONE?u=googlescholar&sid=googleScholar&xid=53b730bb>
- Duque, G., Roberts, A., Hui, J., Posel, N., Fleischer, D., & Chiu, W. (2006). From the facts to the screen: A blended model of teaching basic hospital skills to 2nd year medical students. *Medical Teacher*, 28 (8), 729 – 733. <https://doi.org/10.1080/01421590601032450>
- Ellaway, R., & Masters, K. (2008). AMEE Guide 32: E-Learning in medical education Part 1: Learning, teaching and assessment. *Medical Teacher*, 30 (5), 455 – 473. <https://doi.org/10.1080/01421590802108331>
- Felder, E., Fauler, M., & Geiler, S. (2013). Introducing e-learning/teaching in a physiology course for medical students: Acceptance by students and subjective effect on learning. *Advances in Physiology Education*, 37 (4), 337 – 342. <https://doi.org/10.1152/advan.00158.2012>
- Frehywot, S., Vovides, Y., Talib, Z., Mikhail, N., Ross, H., Wohltjen, H., Bedada, S., Korhumel, K., Koumare, A. K., & Scott, J. (2013). E-learning in medical education in resource constrained low- and middle-income countries. *Human Resources for Health*, 11 (4), 1 – 15. <https://doi.org/10.1186/1478-4491-11-4>
- Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*, 7 (2), 95 – 105. <https://doi.org/10.1016/j.iheduc.2004.02.001>
- Gazibara, T., Marusic, V., Maric, G., Zaric, M., Vujcic, I., Kusic-Tepavcevic, D., Maksimovic, J., Maksimovic, N., Denic, L. M., Grujicic, S. S., Pekmezovic, T., & Grgurevic, A. (2015). Introducing E-learning in epidemiology course for undergraduate medical students at the Faculty of Medicine, University of Belgrade: A pilot study. *Journal of Medical Systems*, 39 (10), 121. <https://doi.org/10.1007/s10916-015-0302-7>
- Gray, K., & Tobin, J. (2010). Introducing an online community into a clinical education setting: A pilot study of student and staff engagement and outcomes using blended learning. *BMC Medical Education*, 10 (1). <https://doi.org/10.1186/1472-6920-10-6>
- Haag, M., Maylein, L., Leven, F. J., Tönshoff, B., & Haux, R. (1999). Web-based training: A new paradigm in computer-assisted instruction in medicine. *International Journal of Medical Informatics*, 53 (1), 79 – 90. [https://doi.org/10.1016/S1386-5056\(98\)00118-X](https://doi.org/10.1016/S1386-5056(98)00118-X)
- Hannafin, M. J. (1984). Guidelines for determining locus of instructional control in the design of computer-assisted instruction. *Journal of Instructional Development*, 7 (3), 6 – 10.
- Hannafin, M., & Land, S. M. (1997). The foundations and assumptions of technology-enhanced student-centered learning environments. *Instructional Science*, 1225 (May), 41 – 42. <https://doi.org/10.1023/A>
- Henry, J. B. (1990). Computers in medical-education – information and knowledge management, understanding, and learning. *Human Pathology*, 21 (10), 998 – 1002. [https://doi.org/10.1016/0046-8177\(90\)90249-5](https://doi.org/10.1016/0046-8177(90)90249-5)
- Hungary, T. C. for a N. P. H. in, & Tempus Consortium for a New Public, T. (1992). Computer communication for international collaboration in education in public health a. *Annals of the New York Academy of Sciences*, 670 (1), 43 – 49. <https://doi.org/10.1111/j.1749-6632.1992.tb26073.x>
- Kearsley, G. (1999). A Guide to Online Education, 1997; Dennis A. Trinkle, “Distance Education: A Means to an End, No More, No Less,” *The Chronicle of Higher Education*.
- Lapidus, M., McCord, S. K., McCloskey, W. W., & Kostka-Rokosz, M. D. (2012). Combined Use of Online Tutorials and Hands-On Group Exercises in Bibliographic Instruction for Pharmacy Students. *Medical Reference Services Quarterly*, 31 (4), 383 – 399. <https://doi.org/10.1080/02763869.2012.724277>
- Lewin, L. O., Singh, M., Bateman, B. L., & Glover, P. B. (2009). Improving education in primary care: Development of an online curriculum using the blended learning model. *BMC Medical Education*, 9 (1), 1 – 7. <https://doi.org/10.1186/1472-6920-9-33>
- Lim, D. H., Morris, M. L., & Kupritz, V. W. (2007). Online vs. blended learning: Differences in instructional outcomes and learner satisfaction. *Journal of Asynchronous Learning Networks*, 11 (2), 27 – 42. <https://doi.org/184.168.109.199>

- Nagle, B. M., McHale, J. M., Alexander, G. A., & French, B. M. (2009). Incorporating scenario-based simulation into a hospital nursing education program. *Journal of Continuing Education in Nursing, 40* (1), 18 – 25. <https://doi.org/10.3928/00220124-20090101-02>
- Nartker, A. J., Stevens, L., Shumays, A., Kalowela, M., Kisimbo, D., & Potter, K. (2010). Increasing health worker capacity through distance learning: A comprehensive review of programmes in Tanzania. *Human Resources for Health, 8*, 1 – 10. <https://doi.org/10.1186/1478-4491-8-30>
- Oh, E., & Lim, D. (2005). Cross relationships between cognitive styles and learner variables in online learning environment. *Journal of Interactive Online Learning, 4* (1), 53 – 66. Retrieved from <http://www.scopus.com/inward/record.url?eid=2-s2.0-24344496925&partnerID=40&md5=acc28e116788a81940037a020911c23b>
- Ohn, M. H., Ravindran, B., Wei, C. Z., Ohn, K. M., & Luen, N. P. (2020). A systematic literature review on technology-enhanced learning in medical education. *Borneo Journal of Medical Sciences, 14* (1), 3 – 17. <https://doi.org/10.51200/bjms.vi.1898>
- Osguthorpe, R. T., & Graham, C. R. (2003). Blended learning environments. *Quarterly Review of Distance Education, 4*, 227 – 233. <https://www.learntechlib.org/p/97576/>
- Piemme, T. E., & Blumenthal, M. (2016). Computer-Assisted Learning Evaluation in Medicine.
- Popovic, N., Popovic, T., Dragovic, I. R., & Cmiljanic, O. (2018). A Moodle-based blended learning solution for physiology education in Montenegro: A case study. *Advances in Physiology Education, 42* (1), 111 – 117. <https://doi.org/10.1152/advan.00155.2017>
- Rudestam, K. E. E., & Schoenholtz-Read, J. (2003). Handbook of online learning. *British Journal of Educational Technology, 34* (4), 536. <https://doi.org/10.1111/1467-8535.03489>
- Seluakumaran, K., Jusof, F. F., Ismail, R., & Husain, R. (2011). Integrating an open-source course management system (Moodle) into the teaching of a first-year medical physiology course: A case study. *Advances in Physiology Education, 35* (4), 369 – 377. <https://doi.org/10.1152/advan.00008.2011>
- Sharma, P., & Barrett, B. (2010). Blended learning: Using technology in and beyond the language classroom. *Survival, 11*, 1 – 5. <https://doi.org/10.1177/0033688206071311>
- Smaldino, S. E., Russell, J. D., Heinich, R., & Molenda, M. (2004). *Instructional media and technologies for learning*. Prentice Hall.
- Suda, K. J., Sterling, J. M., Guirguis, A. B., & Mathur, S. K. (2014). Student perception and academic performance after implementation of a blended learning approach to a drug information and literature evaluation course. *Currents in Pharmacy Teaching and Learning, 6* (3), 367 – 372. <https://doi.org/10.1016/j.cptl.2014.02.017>
- Sun, P. C., Tsai, R. J., Finger, G., Chen, Y. Y., & Yeh, D. (2008). What drives a successful e-learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education, 50* (4), 1183 – 1202. <https://doi.org/10.1016/j.compedu.2006.11.007>