

Review

E-Learning in Pharmacology and Pharmacy

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Abstract: Computer-based learning facilitates a shift from externally controlled to self-directed learning. Universities and other educational institutions are challenged by these developments and must react appropriately to meet the requirements of education. The term e-learning has been coined to describe a wide range of diverse learning and teaching strategies based on the use of electronic devices. Recently developed concepts in the science of education and learning provide appropriate frameworks for novel e-learning scenarios. The present review introduces strategies and concepts for the implementation of e-learning in academic and non-academic programs and gives an overview of current e-learning activities in pharmacology.

Keywords: drug databases; e-learning; further and continuing education; teaching

1. Political and Educational Dimensions of E-learning

A view into the history of information technology shows that the acquisition of knowledge has been linked with technical developments to pass on information. These technical developments represented driving forces of change in society. Some examples are (1) the invention of scripture at the dawn of mankind, (2) the invention of book printing by Johannes Gutenberg in Mainz in the 15th century, and (3) audiovisual technologies (film, photo, videos) in the 20th century. Prospectively, multi-media and computer-based forms of teaching and learning will play an important role in the 21st century.

Computer-based e-learning will facilitate a shift from externally controlled to self-directed learning [1]. Universities and other educational institutions are challenged by these developments and must react appropriately to meet the requirements of education. The internet age brings with it the danger of separating society into those people that have access to internet-based knowledge and those that lack such access. Access to educational resources may determine chances on the employment market. Social ranks in the information era could be defined by access to internet-based information resources rather than by access to means of production and capital, as in the industrial era.

Although the situation has changed during the past decade, sustainable use of electronically accessible information has still not reached its potential in academic education. The internet is a primary information medium for research, but not for teaching. Faced with rapid global developments in information technology, the question is not whether internet-based lectures, seminars, and courses should or should not be offered to the students, but rather how the possibilities of their multimedia design can best be used. Online learning options have been identified as a key feature to strengthen the profile of universities [2,3]. However, there are some framework conditions that challenge universities [4-7].

2. Concepts of E-Learning

Electronic media revolutionized biomedical research. Groundbreaking progress has been made by telemedicine and telepharmacy in the treatment of patients [8-10]. Rather than reporting on electronic media in research, the present review focuses only on e-learning. Electronic learning ('e-learning') comprises all forms of electronic or digital media for presentation and distribution of learning material and for electronic communication. Institutional e-learning modes are:

- (1) Governmental universities, which supplement their traditional portfolio by e-learning. Computer-based learning possibilities vary in terms of intention and organization:
 - (a) add-on models to supplement traditional face-to-face teaching
 - (b) mixed mode models ('blended learning'): some parts (e.g., lectures) are offered online, others are not (e.g., practical seminars).
 - (c) distance education: internet-based programs for undergraduates as well as further and continuing education.
- (2) Private educational institutions. Distance universities ('open universities') offer accredited programs and degrees. E-learning represents considerable progress compared to the shipping of classical paper-based lessons by regular mail.
- (3) Corporate enterprises require continuing education of employees. Sometimes, e-learning courses are more economical than traditional face-to-face teaching. Furthermore, e-learning can be used in a location and time-independent manner, e.g., at home outside of regular work hours.

3. Didactics of E-Learning

Existing didactical concepts are not directly transferrable from traditional teaching to e-learning. The independence from space and time associated with e-learning represents a striking difference.

Hence, e-learning fosters autonomous learning more than classical learning scenarios do. Novel didactical models have to be developed to meet these specific requirements [11-14].

Three major learning theories are discussed in educational science: behaviorism, cognitive science and constructivism. Though all three models are applicable to e-learning, many educational scientists value constructivistic approaches as most adequate.

Behavioristic theory holds that learning is based on stimulus-reaction patterns [15]. Stimuli (teaching content) are processed by the brain leading to certain reactions (learning success). Learning represents a behavioral adaptation to changing stimuli. Learning is understood as an externally directed process.

Whereas the brain is more or less excluded in the behavioristic theory as a “black box,” it moves into the foreground in cognitive science, which places an emphasis on understanding information processing in the brain [16-18]. Noam Chomsky was the founder of cognitive science in psychology.

Cognitivist didactics try to mediate knowledge and foster active thinking by providing optimal learning environments. To reach this goal, complex learning arrangements are provided to stimulate question and search processes and to help learners develop their own effective learning strategies. The development of social competences is fostered by learning in groups. Cognitivist theory advocates finding a balance between externally directed (teacher-centered) and self-directed (student-centered) instructions [19].

A basic thesis of constructivism is that there is no objective truth. Reality is differently perceived by each individual and is, therefore, subjective. Reality is constantly changing and each individual constructs his/her own realities. Learning enlarges existing knowledge and is influenced by the individual biographical background of each learner. Hence, gaining knowledge is not an external process (as in cognitive science), but is internally driven (self-directed learning). Learners, rather than teachers, are responsible for learning success. The teacher only gives support. Therefore, constructivistic didactics try to optimize individual acquisition of knowledge by using complex problems and fostering active understanding and personal interpretations. In addition to suitable didactic scenarios for internet-based learning, technical content must be provided. Several types of software are available for this purpose:

- (1) Presentation software for illustration of data by teleteaching (with or without audience participation), videoconferences and webinars, lectures/videos on-demand as well as lecture supplements with multi-media components (3D-presentation, animations, hypertext, hypermedia);
- (2) Drill and test software for consolidation and practice of learned content, including tasks and tests with questions and answers and interactive practice programs;
- (3) Tutorials are another learning tool also useful for e-learning, e.g., supervised working groups with synchronous or asynchronous communication via internet;
- (4) Simulations reproducing complex conditions to gain experiences close to reality, e.g., simulations: virtual companies, stock exchanges, business games, process simulations, excursions *etc.* Telematics and virtual laboratories can be used to run real or virtual machines by computer. Micro-worlds construct complex situations for simulations.

Recently, scientists and health professionals have made use of e-learning in pharmacology and related fields. This area can be divided into three categories: (1) undergraduate education at

universities, (2) postgraduate education at universities, and (3) courses from educational institutions outside of universities. Searching the Pubmed database (<http://www.ncbi.nlm.nih.gov/pubmed>) with the key words “e-learning” and “pharmacy/pharmaceutical/pharmacology/pharmacological” provides a number of e-learning activities initiated in the past few years, which are the basis for the following chapter. E-learning initiatives on drug treatment are not restricted to pharmacists and pharmacologists, but also include related fields such as under- and postgraduate education of nurses and physicians. Although not described in this review, it should be mentioned that pharmacology-related e-learning initiatives have been established in many universities without publishing their experiences in scientific journals. This may be due to the fact that educational topics are not published with the same frequency in scientific journals as experimental or clinical data.

4. Undergraduate Education at Universities

E-learning has supplemented existing programs in pharmaceutical sciences (‘blended learning’). The mixture of diverse forms of learning increases the attractiveness of programs in pharmacology.

The ETH Zürich and the University of Basel, Switzerland, implemented an e-learning-based curriculum for pharmaceutical sciences [20]. Educational aims are basic knowledge about cognition of drugs, safe drug handling and novel therapeutic and diagnostic methods.

Sancho and co-workers combined traditional practices and e-learning to teach microbiological methods to pharmacy students [21]. Virtual laboratory modules were used to non-manually acquire skills. Learning achievement was evaluated via case-based questions about microbiological problems. Students’ perceptions were obtained by assessment questionnaires.

Undergraduate students in pharmacy and neuroscience were offered an e-learning package in common pharmacology with a cumulative computer-based assessment [22]. Students were asked by a questionnaire for evaluation and their responses were generally positive. There were no significant differences between responses from pharmacy and neuroscience students.

Takeda and colleagues developed a self-learning system for lectures and basic operations in laboratory practice of chemistry [23]. A survey of 26 students revealed that e-learning deepened knowledge and skills in experimental operations. On the other hand, a majority of students also voted for the continuation of demonstration experiments in laboratory practice. This clearly indicates a preference for blended learning compared to stand-alone e-learning.

Clinical pharmacology at the Leiden University Medical Centre is primarily taught by the Teaching Resource Centre’s (TRC) Pharmacology database [24]. Nearly each course has a chapter in the TRC database for self-study. Interestingly, time spent using the TRC database was positively correlated with students’ grades. Students with above average exam scores logged in to TRC more frequently. However, students with lower exam scores derived greater benefit from the database.

Tse *et al.* developed an internet-based e-learning course for nursing students on the integration of pathophysiology into pharmacology [25]. At the end of the semester, the nursing students were given a questionnaire and the outcome was positive. The students were able to understand rather than simply memorize concepts, and they developed problem-solving and critical thinking abilities.

5. Postgraduate Education at Universities

The educational mission of universities also includes further and continuing education for postgraduate students and professionals after years of working experience. E-learning is attractive for life-long learning. E-learning courses for this purpose have been reported in clinical pharmacy and pharmacology, e.g., for junior doctors in hospitals, nurses, pharmacy practitioners, hospital physicians, other health professionals and patients.

Junior doctors sometimes feel poorly prepared in clinical pharmacology and therapeutics. O'Shaughnessy *et al.* distributed an online questionnaire on clinical pharmacology and therapeutics in the United Kingdom [26]. Thirty out of 32 medical schools responded to this online poll. The evaluation showed that teaching was done by clinicians and clinical pharmacists performing classical lectures (90%). Interestingly, 50% of the medical schools reported using additional e-learning, indicating the attractiveness of blended learning for postgraduate education.

The University of Sydney, Australia, applied an online alternative to an existing face-to-face workshop in continuing education preparing practitioners for accreditation as pharmacotherapy prescribers for opioid dependence [27]. A pre-test/post-test control group design was used with 62 participating practitioners to compare outcome measures of knowledge, skill and attitude between online and face-to-face course participants. The online course was equally as effective as the face-to-face mode in preparing participants for their role in treatment and management of opioid dependence and was also rated highly by participants.

In a French survey, 300 physicians representing five main French regions and hospital types were asked to assess the duration, methods, financing, and needs of continuing medical education events [28]. The survey showed that the physicians took part in many educational programs despite organizational, personal, and financial issues. Seminars were preferred for continuing education programs, and interactive workshops and e-learning methods were requested for the future. E-learning facilitates continuing education for professionals. Leikola and colleagues designed a 1.5 year curriculum for practicing pharmacists combining e-learning and face-to-face learning [29]. The objective was to implement a long-term continuing education course for pharmacy practitioners to acquire competency in and accreditation for conducting collaborative comprehensive medication reviews (CMR). The course consisted of five modules: (1) Multidisciplinary Collaboration, (2) Clinical Pharmacy and Pharmacotherapy, (3) Rational Pharmacotherapy, (4) CMR Tools and (5) Optional Studies. Almost all respondents (92%) indicated that their educational needs had been met. Working with peers and in small groups facilitated learning, indicating that both blended learning and stand-alone e-learning should be supplemented by group-based learning.

A number of e-learning activities are available for other health care professionals, such as nurses. Yeoh *et al.* evaluated a blended learning approach to train nurses to administer metoclopramine following morphine administration in emergency departments [30]. A 19-slide e-learning module accessible via the institutional intranet, supplemented by in-service training and a range of reminder techniques (posters, e-mails, and drug room flyers) was offered. Primary read-out was the proportion of patients prophylactically administered metoclopramine with their initial morphine dose. Both pre- and post-intervention evaluation periods were of three month duration. A significant improvement in the evidence-based use of metoclopramine was recorded.

An e-learning program to enhance nurses' medication administration performance was introduced by Sung *et al* [31]. After participation in the program for one month, the survey responses of 34 nurses were analyzed. The nurses' knowledge of medication dispensation was greatly improved after this program. Carbonaro and co-workers investigated whether inter-professional team process skills traditionally taught in small group face-to-face classroom settings were transferable to blended learning environments [32]. Seventy percent of the instructions were delivered by synchronous virtual classroom technology. No significant differences were observed between the blended learning format and the traditional face-to-face format in the development of inter-professional team knowledge, skills, and attitudes.

Efforts to reduce injuries associated with patient handling are often based on tradition and personal experience rather than on sound educational theory. Wanless and Page summarized the evidence for educational interventions designed to reduce primary care staff injuries, which have been a significant problem for decades [33]. Classical classroom teaching of moving and handling was found to be ineffective, but motion-capture simulations and e-learning improved practice.

Laustsen *et al.* promoted alcohol-based hand rubbing by e-learning among university hospital staff [34]. Participants had a significantly higher adherence to correct hand rubbing before and after clinical procedures than non-participants. E-learning programs may help to prevent health care-related infections and meet the demands of lifelong education and training of hospital staff.

E-learning represents a component of telemedicine. An illustrative example has been reported by Chapman *et al.* [35]. Radiotherapy is an important option for cancer treatment. In New South Wales, Australia, the referral base for many radiation oncology departments extends across rural and remote regions. Resources for care and support of patients undergoing radiotherapy available to general practitioners are limited in these rural areas. The authors developed an e-learning information resource for (1) health professionals and patients in rural New South Wales on general radiotherapy information and (2) general practitioners on the specifics of radiation-induced side effects. Similar efforts may meet the requirements for telemedicine applications, e-learning skills and medicinal informatics in Morocco [36].

6. E-Learning Activities of Other Educational Institutions

Continuing and further education is not only important for universities. Organizations and enterprises also have to provide information to their members and employees. The World Health Organization (WHO) developed a week-long experimental learning event to teach participants how temperature-sensitive products should be handled, stored and distributed [37]. A program called "Pharmaceutical Cold Chain Management on Wheels" was offered to team members working together and to several global expert mentors, who were available to guide learning and answer questions. The factors contributing to the success of this learning experiment may also have relevance for other e-learning events.

The Italian Drug Agency sponsored a free-access e-learning system based on clinical evidence, called ECCE [38]. Doctors have access to an electronic version of the system and related clinical vignettes. Correct answers to the interactive vignettes provide Continuing Medical Education credits. The aim was to investigate whether ECCE increased physicians' basic knowledge of common clinical

scenarios and whether e-learning was superior to passive diffusion of information through a printed program.

Enterprises frequently coach their employees in e-learning-based courses [39]. Mitsuhashi *et al.* performed a survey of 134 Japanese enterprises [40]. Among them, 19 % had already introduced e-learning for continuing education and 16 % planned using e-learning in the future. Although the vast majority of enterprises were open-minded towards e-learning for occupational safety and health topics, those that had already established e-learning courses on this topic were in the minority. The study indicated a clear need for more e-learning-based education. Improvement of e-learning platforms and content, cost reduction and improvement of e-learning infrastructure at work will further facilitate e-learning at enterprises.

Karp [39] reports on an application service provider (ASP) model with an e-learning platform enabling pharmacists and pharmacy technicians to fulfill continuing education requirements in order to receive their state licenses and certifications. As the demand for continuing education for professional licensure, re-licensure and certification grows, e-learning is convenient for healthcare professionals, since they can access course content from anywhere at any time. Furthermore, e-learning eliminates travel costs and shortens the amount of time that employers and employees spend away from their jobs.

7. Conclusions and Perspectives

E-learning represents a thriving new supplement to traditional face-to-face learning in undergraduate and graduate programs as well as to postgraduate programs at universities, hospitals, or in industry. It is especially important for postgraduates because it allows them to take advantage of continuing learning programs without interrupting their work.

E-learning in pharmacology is still in its infancy. Although promising results have been reported, there are still unresolved questions. A major issue is how to measure the success of e-learning in the short and long-term. In the short-term, evaluation of e-learning programs is easily possible by examinations either on-line or in “real life” as oral or written examinations. The conceptual problem, if one accepts that constructivist learning scenarios are best suited for e-learning, is however, that traditional examinations have a strong background in cognitive learning theory. Hence, suitable modes of evaluation of e-learning success must be developed. To realize this goal, a close collaboration between educational professionals on one side and pharmacologists and pharmacists on the other side is necessary. We estimate that the challenge to realize e-learning may lead to a significant advancement of e-learning programs.

Furthermore, sustainable concepts have to be developed to cope with educational requirements, technical developments, the needs of learners, institutional frameworks and last but not least, budgetary conditions. Social requirements (e.g., education oriented to employment markets) and specific scientific priorities (e.g., basic science-oriented education) have to be balanced.

The further implementation of e-learning in pharmacology requires:

- (1) Novel mobile technologies such as tablets and smartphones, which may further facilitate the establishment of e-learning-based programs as recently shown (www.srh-hochschulen.de);
- (2) Establishment of high performance nets (ATM) and wireless nets (W-LAN, WiFi);

- (3) A better usage of facilities and resources (placement in practical courses, lecture halls *etc.*);
- (4) Production and distribution of e-learning offers;
- (5) Educational research: What are the differences between e-learning and classical education? Which strategies best facilitate acquisition, selection and structuring of information for e-learning?

E-learning bears new possibilities for exploring learning. It is not only independent of space and time; the speed of learning can also be individually adapted to the previous knowledge and special needs of students. Complex content can be communicated in an illustrative and understandable manner by multiple modes of presentation as compared to classical forms of teaching (e.g., images, text, graphics, animation, simulation, language, music). However, care must be taken to avoid cognitive overload. Computer-based learning trains independence and responsibility. However, tutorial supervision is necessary to avoid excessive self-demands by learners. New forms of learning such as hypertexts, hypermedia, interactive 3D-simulations and synchronous and asynchronous communication (videoconferences, blogs, discussion platforms, webinars) may be stimulating. E-learning will only be sustainable in an everyday academic routine if its additional value as compared to traditional forms of teaching and learning is obvious. A close collaboration between e-learning tutors/instructors, information scientists and pharmacists and pharmacologists is necessary to generate ambitious e-learning programs. It will be exciting to further observe the development of e-learning-based education in pharmacology in the years to come.

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