RESIDENT & FELLOW SECTION

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Opinion and Special Articles: Electronic media in neurology education

Progress, promise, and pitfalls

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Today's neurology learners have more information to assimilate than ever before,[1] requiring them to learn as quickly and efficiently as possible, while also becoming lifelong learners. To facilitate more effective and expedient learning, neurology educators have begun using computer-assisted learning technologies in education and residency. Electronic media have been found to be effective additions to education due to their flexibility, scalability, timeliness, and adaptability.[2] Computer-based learning is increasingly employed by medical students, neurology trainees, and practicing neurologists, making it necessary to acclimate students and trainees to such technology before they enter professional practice.

Favorable results have been achieved using electronic learning tools in neurology, but some studies have revealed limitations in their effectiveness. This article looks at evidence that supports and sometimes calls into question the use of technology in neurology education, concluding with how technology could be effectively integrated into neurology education.

COMPUTER-AIDED LEARNING IN NEUROLOGY EDUCATION Neurology residents develop clinical competency during training by acquiring the necessary skills, knowledge, and ethos as required by the Accreditation Council for Graduate Medical Education, but they must also be prepared to both maintain and update their knowledge throughout their careers.[3] Ensuring that every resident receives the necessary level of training to maintain these standards is challenging, particularly in light of increasing work hour restrictions and the vast number of topics that must be covered, including systems-based practice issues. Developing effective and time-efficient learning tools is paramount in this residency training era.

Simulation technology is a useful supplement to traditional training. Specifically, anatomic and pathologic simulators, procedural skills simulators, and surgical simulators have proven to be effective in training residents. Simulators may aid residents in learning anatomy, clinical and diagnostics skills, as well as consultation skills. There are ongoing opportunities to expand the use of simulators in neurology. The specialty of neurocritical care is already adapting this technology in providing residents with "hands-on" experience through the use of mannequins that simulate human responses.[4] This type of critical care training is beginning to replace or at least build upon traditional lecture learning.

Living in such a technological world, today's neurologists have access to numerous databases to assist with diagnosis and treatment. A Google search alone can aid with diagnosis in about half of challenging neurology cases.[1] As the internet continues to embrace Web 2.0 technology, these tools will become more interactive, collaborative, and useful in neurology.[1]

Even textbook learning has been improved upon, resulting in better medical learning. Medical students at the University of Kentucky College of Medicine were supplied with a written and electronic medical neuroscience text that was enhanced with various media.[5] Ninety-nine percent of the students reported that the electronic multimedia guide enhanced their learning and improved their test scores. Eighty-nine percent felt that the guide reduced their study time. Multimedia texts and portable, less expensive e-books are likely to be increasingly integrated into future curriculum tools.

A Johns Hopkins School of Medicine study similarly found that gross anatomy students both enjoyed technology in their learning and benefitted from it.[6] It showed that students found the Web-based media-enriched learning to be nearly 30% more user-friendly and useful than lecture alone. In fact, many of the students in this study asserted that the media pieces were critical in helping them learn the material. This is important because the more involved and interested students are in the material the better they will learn it, and the more they will be able to build that knowledge into their understanding of neurology. On the other hand, others caution that student satisfaction surveys are not a proper measure of learning effectiveness, implying a need for more research into effectiveness of learning over satisfaction.[7] Grisold et al.[8] further assert a need for electronic sources in lifelong learning, recognizing that over the 25- to 30-year career of a neurologist there is continuing

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need to update medical knowledge to stay relevant and for up-to-date board certification. The American Academy of Neurology (AAN) affirms this need through their offering of *Continuum*® via print, online, iPad app, and biweekly audio podcasts with subject experts, and the forthcoming NeuroLearn series of continuing education online courses. In the past, neurologists have used print journals to stay current in their field, but the AAN's convenient delivery platforms maintain high-quality digital resources that are peer-, expert-, or continuing medical education–reviewed. Additionally, NeuroLearn is based upon the assessment model created by Dr. Peter Bergethon at the Laboratory for Intelligence Modeling, Boston University School of Medicine, providing a robust educational series.

Electronic learning media can be adapted to fit the knowledge level of individual students. Elkind[1] wrote that residency rotation requirements must be continually re-evaluated because it is increasingly recognized that trainees learn at different paces, that different clinical settings provide more breadth of experience than others, and that fixed duration rotations do not work for every resident. This concept can also be applied earlier in resident training and may represent one of the most interesting potential changes to medical education. Today's computer-aided learning can be adapted so that a single training module can be given to students of various knowledge levels, allowing them to advance through the work at their own pace. Studies reveal that this effective strategy allows students to learn the most information possible while minimizing their study time by 18% compared to those using nonadaptive electronic educational sources.[2]

PREPARING FOR MODERN NEUROLOGY PRACTICE Neurology is increasingly relying on telemedicine to diagnose and treat patients in areas that lack a practicing neurologist. Specifically, telemedicine has been used successfully in stroke care. Rural hospitals are able to consult with tertiary care center stroke specialists using an audiovisual system to assess patients in real time, as well as view diagnostics allowing for rapid expert diagnosis and treatment. Robotic telemedicine is increasingly utilized in neurocritical care units across the country, not only enhancing rapid responses to deteriorating patients, but also providing cost savings in care.[9]

Neurology residents and practitioners stand to benefit significantly from the use of communications technology. Modern smartphone technology, for example, can allow recording of seizures and other neurologic symptoms for later review.[10] The entire neurology department can make use of podcasts and video conferencing to consult with geographically distributed specialists. Additionally, mobile computing tablets are becoming a staple for neurologists, allowing them unprecedented access to electronic medical records, online information, communications and recording technology, and note taking tools anywhere they go.

Among the most exciting applications of technology in neurology education and practice is remote patient monitoring.[10] Given that practicing neurologists are spending less time in hospitals and more time in outpatient care,[1] it stands to reason that monitoring technology will become more important. Today's technology allows smartphone applications to provide distance viewing of hospital intensive care unit monitors, as well as the potential to track outpatient symptoms and seizure details.[10] Further development is needed, but new applications are being used every day. For example, existing epidemic tracking applications may be able to indicate geographic trends in neurologic disorders,[11] potentially revealing their environmental links.

EDUCATIONAL TECHNOLOGY PITFALLS Increasing the use of technology in medicine is not without detractors. There is appropriate concern that technology can make education and practice seem impersonal, and may distract learners from seeing their patients as complex individuals with personalities, people who seek a human and in-person connection with their physicians.

While many researchers have extolled the virtues of computer-aided learning, not all studies are favorable. Virtual technologies have often been found to be effective but time-consuming.[12] Irish neurology medical students and residents have said they felt that bedside training is more effective than electronic learning,[13] although this study had limitations in sample selection and discounted the potential value of combined traditional bedside training with technology. Despite the occasional challenges, the majority of research has demonstrated that electronic media is improving neurology education and practice.

Some fear that technology is making diagnosis through physical examination a "dying art." Even students have said that they sometimes feel that using electronics during diagnosis can damage the flow of interaction with a patient.[14] Leadership at the Stanford School of Medicine has become concerned that the increased use of technology is a detriment to effective bedside practice. They established small group hands-on sessions to teach certain areas of the physical examination, including neurologic examinations,[15] although ironically, their Web site is replete with instructional videos.

When medical educators talk about technology in education they often are referring to online collaboration and information tools. These types of technology facilitate information sharing, but they also open up roads to misinformation and anecdotal and unsubstantiated

evidence.[16] To avoid falling prey to these pitfalls, it will be necessary for educational and health institutions to provide training and oversight of physicians and trainees as they navigate the Internet for information and patient care issues.[16]

THE PROMISE OF TECHNOLOGY IN NEUROLOGY EDUCATION Students enjoy technology-based learning and find it valuable.[1,14,16] This satisfaction level for students is important if they are to remain engaged with their medical education over the course of a lifetime.[17] Traditional learning will need to be integrated with technology in order to stay relevant.[17]

Technological tools cannot be effective in a vacuum; they must become part of an integrated curriculum. As Chan and Robbins[18] wrote, "Internet-based learning software is another tool in the educator's armamentarium. Educators must still utilize sound educational pedagogy to create effective learning instruments." They point out that the mere availability of software and media does not ensure its effective use. Technology and media must be an effective part of a wholistic pedagogy.

When used effectively, asynchronous and synchronous communications technologies such as blogs, wikis, and podcasts may improve residents' ability to understand patient's conditions and collaborate with instructors and peers, deepening their learning.[19] While many programs have experienced anecdotal success with various forms of learning and engagement technology, there is still a need for empirical research in order to provide evidence-based support for the continuing use of technology in medical education.[19]

Table Comparison of traditional vs technology-based medical learning and practice

Traditional learning and practice	Technology-based learning and practice
Students only learn when in class/residence or when reading texts.	Students can be active and engaged 24 hours a day, 7 days a week.
Traditional communications technologies limit one to synchronous time and geography.	Wikis, blogs, and other communications tools offer the ability to quickly and easily collaborate and share information.
Past students knew no differently than traditional education and practice.	Modern students expect technology to be part of their learning and adapt well to it.
Traditional neurologists were largely limited to consulting with other doctors in their own facility, with limited access to geographically distributed colleagues.	An increased knowledge base in neurology makes it difficult for any one person to know everything; with modern technologies it is possible to consult with other professionals around the world.
Traditional residencies revolved around interaction with patients.	Some people believe that patient interaction could be lost.
Traditional students were limited to learning from textbooks, lectures, and bedside practice.	The increased knowledge base and modern work hour restrictions necessitate the use of more expedient and engaging learning methods.
Respected printed journals used for professional development were peer-reviewed or expert-reviewed and available in print only.	Modern digital resources for professional development, such as the American Academy of Neurology's *Continuum*® and NeuroLearn, are peer-, expert-, or continuing medical education–reviewed. Comprehensive online databases are also available.
Educators have to create their own modules and training sessions, causing every instructor to spend lengthy times on planning and instructional design.	Modules can be shared between faculty and even between institutions, reducing the duplication of effort.

A NEW ERA IN NEUROLOGY EDUCATION Today's medical students and residents are mobile targets, multitasking, working various positions, and often serving populations that are far from their instructor and parent learning institution. Similarly, in modern practice clinicians are often called upon to venture to far locations, working in remote areas without proper academic and peer support.[19] Thus, modern collaboration technologies can be used to provide diagnostic and social support, helping medical students to be more successful in their learning and professional practice.[19] To be certain, the most effective way to use modern technology will be in concert with traditional learning methods, allowing bedside training to be augmented by Web-based learning. The table shows a comparison of traditional learning and learning technologies; this comparison shows some of the positives and negatives of each type of learning design.

Despite our assertion that the use of electronic media in neurology education is here to stay, it is important to recognize that research continues to be needed to determine the most effective ways to utilize technological tools within neurology education. Modern technology should be the beginning of bettering education, not an end in itself; it is important that medical educators work to merge technology with traditional education. Collaborative learning tools and the availability of learning media should help students construct their own knowledge and build their skills.[19] As Elkind[1] asserted, the education of neurologists needs to change in order to adapt to new regulatory requirements and the sheer volume of information to be learned. Various technologies have repeatedly been demonstrated to be effective and time-efficient learning, diagnostic, and communications tools for today's neurology residents. The computer revolution has only just begun to affect neurology education.

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Shaheen E. Lakhan: drafting/revising the manuscript, accepts responsibility for conduct of research, and will give final approval. Deborah Tepper: drafting/revising the manuscript, accepts responsibility for conduct of research, and will give final approval. Rebecca D. Snarski: drafting/revising the manuscript, accepts responsibility for conduct of research, and will give final approval. MaryAnn Mays: drafting/revising the manuscript, accepts responsibility for conduct of research, and will give final approval.

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