Test-Enhanced Learning in Flipped Classroom

Julie L. Huffmyer, MD, and Edward C. Nemergut, MD

In this issue of *Anesthesia & Analgesia*, Vasilopoulos and colleagues[1] present the results of an educational study where the authors used podcasts to teach basic electroencephalograph (EEG) interpretation. The authors administered a 25-item multiple-choice test to anesthesiology residents and fourth year medical students at baseline, after podcast viewing, and after a practical EEG interpretation session with a neurophysiologist. At each evaluation stage, the test scores progressively increased. Those learners with a history of more podcast experience (4 or more previous podcasts) showed greater increase in scores compared with those learners with less podcast experience (3 or fewer). While this study possesses compelling results regarding the use of podcasts as an EEG teaching tool, it also demonstrates the effective use of 2 novel teaching techniques: test-enhanced learning and the "flipped" classroom.

TEST-ENHANCED LEARNING

In medical education in the United States, especially graduate medical education (GME), multiple-choice tests have been used almost exclusively as an assessment tool. For generations, successful performance on multiple-choice tests has served as mandatory milestones for continued advancement in medicine. In anesthesiology, candidates must successfully pass both the American Board of Anesthesiology BASIC and ADVANCED examinations to obtain primary board certification. Current diplomats must pass the American Board of Anesthesiology Cognitive Examination every 10 years to maintain board certification in anesthesiology (Maintenance of Certification in Anesthesiology).

In this study, the authors used a multiple-choice test at each stage for the primary purpose of objective learner assessment. The tests were used to document that the subjects were learning something about EEG at each stage. But, is there more to testing than assessment?

There is emerging evidence from cognitive science that strongly suggests that testing may be a very important component of learning.[2] Tests, especially pretests, can enhance and alert memory. In 2008, Karpicke and Roediger[3] demonstrated the impact of testing on outcome in a foreign language construct. After being exposed to the English translation of 40 Swahili words, students were randomized to 4 groups. Two groups focused most strongly on repeated testing for subject mastery. Two groups relied more on studying for mastery, not testing. At the end of the initial learning phase, all students in each of the 4 groups had mastered all 40 Swahili words. When the students were retested 1 week later, those students who had repeated testing recalled about 80% of the Swahili words. In contrast, those students randomized to groups that focused on studying (i.e., those students who had not been tested as part of the mastery process) recalled only about one-third of the Swahili words.[3] The authors concluded "testing (and not studying) is the critical factor for promoting long-term recall."[3] Amazingly, the differences between testing and studying can even be appreciated using functional magnetic resonance imaging of the brain![4]

In a similar study, Halamish and Bjork[5] demonstrated that cued-recall testing enhanced final examination performance more than studying. Importantly, the authors noted that the effect was greatest when the final examination was most difficult, suggesting that the efficacy for repeated testing is greatest with complicated subjects. The authors concluded that "when there is a fixed amount of time that can be spent restudying or testing, the more difficult the anticipated criterion test, the more initial testing should be chosen."[5]

In Fahy and colleagues[6,7] body of work regarding EEG instructional models,[8–10] long-term retention has been an important area of focus. In 2014, Fahy and colleagues[11] noted that much information acquired during residency training must be recalled months or even years after it is initially learned. In that multidisciplinary EEG study, they found that more EEG interpretations with repeated testing over an extended time period resulted in improved long-term retention.[11] While developing the Voyager aircraft (the first aircraft to fly around the world without stopping or refueling in 1984), aerospace engineer Burt Rutan said, "Testing leads to failure, and failure leads to understanding." In the end, learning in any subject may be just that simple.

THE FLIPPED CLASSROOM

The "flipped classroom" is a novel approach to learning where students watch lectures online and at their own pace, typically at home. Class is then reserved for active learning exercises and interactive activities, which illustrate important concepts. The role of the teacher is expanded, and teachers are expected not to merely observe and assess but to actively engage students. The flipped approach has been widely used in medical schools but has been used much less frequently in GME. The process relies on technology

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as students must have Internet access to view online content and teachers must have the capability and technical resources to produce this content.

In 2012, Prober and Heath[12] published a powerful editorial in the *New England Journal of Medicine* entitled, "Lecture Halls without Lectures—A Proposal for Medical Education." In the editorial, the authors note that despite all the advancements in technology that have occurred over the past 100 years, medical students and residents are still being trained to be doctors in "roughly the same way they were taught when the Wright brothers were tinkering at Kitty Hawk."[12] While duty-hour restrictions have reduced the amount of time available for educators to teach and the sheer volume of material and information we expect our students and residents to master has increased, effective, time-efficient education represents a daunting charge to those in medical education. Prober and Heath[12] suggest that we must find ways to "make our lessons stickier" and introduce the concept of the flipped classroom as a preferred approach.

The study by Vasilopoulos and colleagues[1] is a perfect example of a modern approach to education: it uses both a flipped classroom and test-enhanced learning, although it does not explicitly call attention to these educational techniques. In the study, anesthesiology residents and fourth year medical students viewed podcasted lectures at home before an interactive session with a neurophysiologist and were tested repeatedly between educational activities. The pairing of podcasted lectures, active learning and frequent, repeated testing is exactly what GME should include in 2015. That is the power of the current study. It is about how we should endeavor to teach and train our students and residents. Put simply, it is about the future!

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RECUSE NOTE

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Prior Podcast Experience Moderates Improvement in Electroencephalography Evaluation After Educational Podcast Module

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BACKGROUND: There is continued interest in using technology to enhance medical education and the variables that may affect its success.

METHODS: Anesthesiology residents and fourth-year medical students participated in an electroencephalography (EEG) educational video podcast module. A 25-item evaluation tool was administered before any EEG education was provided (baseline), and the podcast was then viewed. Another 25-item evaluation tool was administered after podcast viewing (after podcast). Ten EEG interpretations were completed with a neurophysiologist with an additional 25-item evaluation tool administered after the interpretations (after 10 EEG interpretations). Participants were surveyed concerning technology and podcasting experience before the educational module and their responses to the podcast educational model. Multiple analyses were performed (1) to evaluate differences in improvement in EEG evaluation scores between the podcast module and the standard didactics (control group); and (2) to evaluate potential moderation by technology and the podcast experience on the change in mean EEG evaluation scores from after the podcast module to after 10 EEG interpretations.

RESULTS: A total of 21 anesthesiology residents and 12 fourth-year medical students participated. Scores on the 25-item evaluation tool increased with each evaluation time ($P \leq 0.001$). Moderation analyses revealed that individuals with more podcast experience (≥4 previous podcasts) had greater increases in scores after a podcast and 10 EEG interpretations compared with individuals with less experience (≤3 previous podcasts) ($P = 0.027$). Furthermore, compared with a control group with similar baseline characteristics that received only standard didactics without a podcast, those in the podcast group had greater increases in mean EEG evaluation scores between baseline and after 10 EEG interpretations.

CONCLUSIONS: In reviewing the improvement in EEG evaluation after a podcast education module, those with more podcast experience achieved greater gains in EEG evaluation scores. For EEG education, those receiving the podcast education module showed greater increases in scores compared with those receiving didactic teaching without podcasting, as measured by change in a mean EEG evaluation scores. (Anesth Analg 2015;121:791–7)

The application of technology to enhance medical education continues to develop. Medical schools are using podcasts as part of their curriculum[1,2] with applications of podcasting described in medical education.[3] Podcasts also are now being used by major medical journals, including the *New England Journal of Medicine*[a] and *Anesthesia & Analgesia*.[4] A recent survey involving Canadian anesthesia residents revealed that the majority of residents had used podcasts for medical education purposes.[5] Although comparisons of many different educational aspects of podcasts have been performed, specific variables that can potentially affect the success of podcasting still warrant further investigation.[6–12] The aim of the present study is to examine podcasting as a tool in electroencephalography (EEG) education and evaluate how access to technology, prior experience with podcasting, and opinions on podcasting moderate the improvement in EEG evaluation after a podcast module.

METHODS

The University of Kentucky IRB approved this prospective study after the Graduate Medical Education Committee granted permission for residents and the University of Kentucky College of Medicine for medical student to participate in the study. All participants provided written consent. Two of the investigators each recorded a lecture for podcasting using the technique previously described,[13] which was then uploaded and published to an iTunesU (Apple Inc., Cupertino, CA) location, allowing the study participants to view the podcast using a Web-based platform on a Mac, iPhone (both from Apple Inc.), and PC (Microsoft

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[a]Available at: http://www.nejm.org/action/showPodcastsFeeds. Accessed May 27, 2014. *New England Journal of Medicine*.

Table 1. Sample Characteristics

Survey question	Frequency (%)
Gender	
Male	69.7
Female	30.3
Background	
Medical student (fourth year)	36.4
Anesthesiology resident	63.6
Which of the following technology do you own?	
Windows desktop or laptop	87.9
Mac desktop or laptop	30.3
iPhone	75.8
iPod	45.5
Other portable media player with video	18.2
Other portable media player without video	9.1
How would you rate your comfort level with technology?	
Very comfortable	57.6
Somewhat comfortable	36.4
Neutral	3.0
Somewhat uncomfortable	3.0
Very uncomfortable	0
Before the EEG podcast, how many times had you used a podcast for educational purposes?	
Never	24.2
1–3 times	24.2
4–6 times	9.1
7–9 times	3.0
≥10 times	39.4
How would you rate the podcast as a learning tool?	
Very useful	66.7
Somewhat useful	27.3
Neutral	6.1
Somewhat useless	0
Useless	0
What do you view as the advantages of podcast material?	
Preparation for assessments	42.4
Supplemental learning materials	66.7
Enable note taking at own pace	63.6
Review of material at own pace	87.9
Repetition (as needed) of material	81.8
Able to view at my convenience	78.8
Potential portability	75.8
None	0
How useful did you find the EEG podcast before EEG interpretations with your instructor?	
Very useful	59.4
Somewhat useful	37.5
Neutral	3.1
Somewhat useless	0
Useless	0
The EEG podcast introduced the EEG concepts at a knowledge that was appropriate for me.	
Strongly agree	31.3
Agree	59.4
Neutral	3.1
Disagree	6.3
Strongly disagree	0
The EEG podcast was easy to understand.	
Strongly agree	34.4
Agree	56.3
Neutral	9.4
Disagree	0
Strongly disagree	0
EEG podcasting was preferable to lecture.	
Strongly agree	28.1
Agree	34.4
Neutral	25.0
Disagree	12.5
Strongly disagree	0

(*Continued*)

Table 1. *Continued*

Survey question	Frequency (%)
Overall I would rate the EEG podcast experience as:	
Very positive	31.3
Somewhat positive	56.3
Neutral	12.5
Somewhat negative	0
Very negative	0

EEG = electroencephalogram.

Corporation, Redmond, WA). The study participants took a baseline evaluation tool before any EEG instruction. After the podcast, another evaluation tool was administered. Study participants then interpreted 10 EEGs with a neurophysiologist with another assessment after completion of 10 EEG interpretations. The investigators developed the EEG evaluation tools with 1 investigator (DFC) creating the initial content and further question development, revision by the clinical neurophysiologist (MB-O), and validation by another investigator (BGF) trained by the National Board of Medical Examiners in item writing development. Each of the evaluation tools had 25 multiple-choice items with similar content. The evaluation tools had unique questions specifically designed to assess the basics of EEG knowledge and interpretation of EEG tracings and then were scored by an independent third party, thus blinding the investigators to individual results.[14] The evaluation tools have previously been shown to be reliable using Cronbach alpha.[15]

Participants also were surveyed about technology, the podcasting experience, and their opinions on the podcast education module (Table 1). Access to mobile technology was indexed by a combined iPhone/iPod ownership variables (yes/no). Prior podcast experience was recoded as either ≥4 times or ≤3 times, with each group containing approximately half of the sample (51.6% vs 48.4%). Finally, the remaining variables of podcast experience and opinions on podcasting were combined in a summary measure. Those variables included "How would you rate your comfort level with technology?"; "How would you rate the podcast as a learning tool?"; "How useful did you find the EEG podcast before EEG interpretations with your instructor?"; "The EEG podcast introduced the EEG concepts at a knowledge that was appropriate for me"; "The EEG podcast was easy to understand"; "EEG podcasting was preferable to lecture"; and "Overall I would rate the EEG podcast experience as: very positive to very negative." Each statement was recoded to a scale of 1 through 5, with a higher number reflecting more positive responses. The average score for this summary variable was 29.4 ± 4.9 (range, 9–35). The internal consistency of this measure was Cronbach's alpha = 0.80. Table 1 also includes background characteristics of the sample, including gender and educational background (medical student, anesthesiology resident).

A repeated-measures linear mixed-effects model was performed to evaluate change in mean EEG evaluation scores after the podcast module. First, a baseline model was fit to the data that included the fixed effects of time and baseline EEG evaluation scores on the change in EEG evaluation scores from after the podcast module to after 10 EEG evaluations. In a second model, variables indexing background characteristics, access to mobile technology, prior podcasting experience, and the podcast experience/summary variable were included as additional fixed effects. To compare the full model (all fixed effects) with the baseline model (only time and baseline EEG score), the model fit was evaluated using the Akaike Information Criteria (AIC), with lower scores indicating better fit.

Additionally, a main goal of this study was to evaluate how background experiences, access to technology, and opinions on podcast education moderate change in EEG evaluation scores after the podcast module. Thus, an interaction term with time was subsequently tested within the mixed-effects model to quantify the moderation by the following measures: iPhone/iPod ownership (yes/no), prior podcasting experiences (≥4 times vs ≤3 times), and the summary podcast opinions measure. A significant interaction with time would indicate that the change in EEG evaluation scores from after the podcast module to after 10 EEG interpretations (i.e., slope) differed across levels of the moderator. A minimal detectable difference of 1.5 points on the educational tool from a total of 25 (6% difference) with the SD at 2.50 at a power of 0.80 (alpha = 0.05) was estimated for our sample, $n = 33$.

To evaluate the differences between this podcast education module and standard didactics, mean EEG evaluation scores at baseline and after 10 EEGs were compared between the sample of present study and a sample ($n = 24$) of residents, ranging from PGY-1 (first-year resident) to PGY-3 (third-year resident) who had similar baseline characteristics to the podcast sample. The podcast sample was 70% male and was assessed between the years 2009 and 2011; the control group was 75% male, as was assessed between 2007 and 2013. All of the individuals in the control group received a didactic education module. They were then evaluated using the same tools used in evaluating the podcast sample. Mixed-effect models were used to assess differences in EEG evaluation score at baseline and after 10 EEGs. These models also were controlled for gender and educational background (e.g., medical student, anesthesiology resident) with year of assessment modeled as a random effect to control for covariation because of cohort membership. Additionally, the second model evaluating EEG evaluation scores after 10 EEG also controlled for baseline EEG evaluation score.

RESULTS

The study participants consisted of 21 anesthesiology residents and 12 fourth-year medical students. Table 1 reports the sample characteristics and participant responses to the survey. Over 70% of the sample was male, with the number of residents exceeding the number of medical students. Most of the sample reported being at least somewhat comfortable with technology. The participants reported a range of previous podcast education experiences, with nearly half the sample reporting ≤3 previous experiences and 40% reported having ≥10 experiences. Over 90% of the sample, when surveyed, found the podcast a valuable learning tool, with it being useful before in-person EEG instruction, and the presentation was at an appropriate knowledge level and easy to understand. Finally, a majority of the sample thought the podcast module was preferable to lecture, with 12.5% in disagreement and 87% of the sample rating the podcast experience positively.

Association Between Podcast Experience and Change in EEG Evaluation Scores

Results from the repeated-measures analysis are reported in Table 2, with time as the only significant predictor of scores on the 25-item evaluation EEG evaluation tool. Scores on the 25-item evaluation tool increased from after podcast to after 10 EEG ($P \leq 0.001$; Fig. 1). However, even though there were no statistically significant estimates for the other predictors and covariates in the model, this model fit the data well compared with the baseline model, AIC = 295.881 vs AIC = 311.881.

Moderation analyses revealed that, for changes in mean EEG evaluation scores after the conclusion of the podcast module, there was a significant interaction between prior podcast experience and time (β = 2.39, SE = 1.03, $P = 0.027$). The mean change in EEG evaluation scores from after the podcast module to after 10 EEGs was greater in the ≥4 times group (mean change = 3.6, SD = 3.22) compared with the change in the ≤3 times group (mean change = 1.75, SD = 3.15). In other words, individuals with more podcast experience before the podcast module showed greater increases in EEG evaluation scores after the podcast module compared with individuals with less prior experience (Fig. 2). Moreover, in comparing the distribution of EEG scores between these groups, both subgroups passed the Shapiro-Wilk test ($P = 0.42$ for the ≥4 times group and $P = 0.10$ for ≤3 times group). Additionally, the variance in EEG scores between these groups was not significantly different ($P = 0.12$). Finally, there was no statistically significant moderation effects found for either time × iPhone/iPod ownership (β = −0.78, SE = 1.42, $P = 0.59$) or time × podcast opinions/views summary score (β = 0.78, SE = 0.54, $P = 0.16$).

Table 2. Multivariate Repeated-Measures Model for Main Effects of Technology and Podcast Experiences on Electroencephalogram Evaluation Scores

Measure	β	SE	P
Intercept	8.22	3.75	0.038
Education background (anesthesiology resident versus medical student)	−0.98	0.79	0.23
Gender	−0.44	0.88	0.62
Time (after podcast to after 10 EEG)	2.53	0.55	<0.001
Baseline EEG evaluation score	0.06	0.14	0.68
iPhone/iPod ownership (yes versus no)	1.31	1.03	0.22
Prior podcast experience (≥4 times versus ≤3 times)	0.48	0.84	0.57
Podcast experience/opinion summary score	0.12	0.12	0.34

Model fit was assessed by Akaike's Information Criteria (AIC). Full model with all predictors: AIC = 295.881; Baseline model with only time and baseline EEG scores (estimates available from author): AIC = 311.881.
EEG = electroencephalogram.

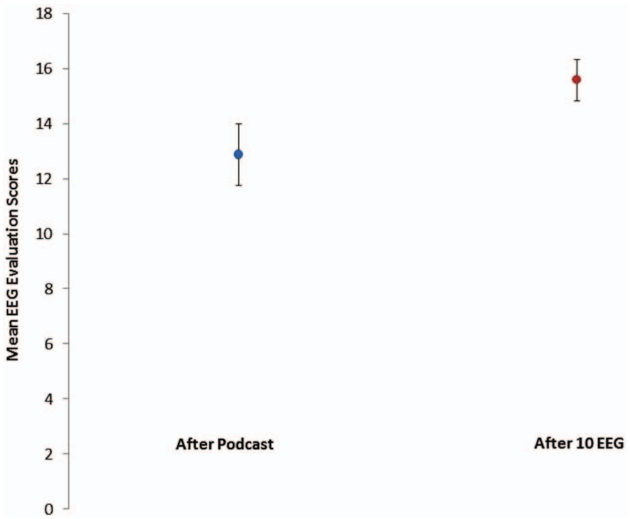

Figure 1. Change in electroencephalogram (EEG) scores during podcast education module (from after podcast module to after 10 EEG readings). Mean scores on the EEG evaluation tool significantly ($P \leq 0.001$) increased after the podcast module completed. Error bars represent 95% confidence intervals.

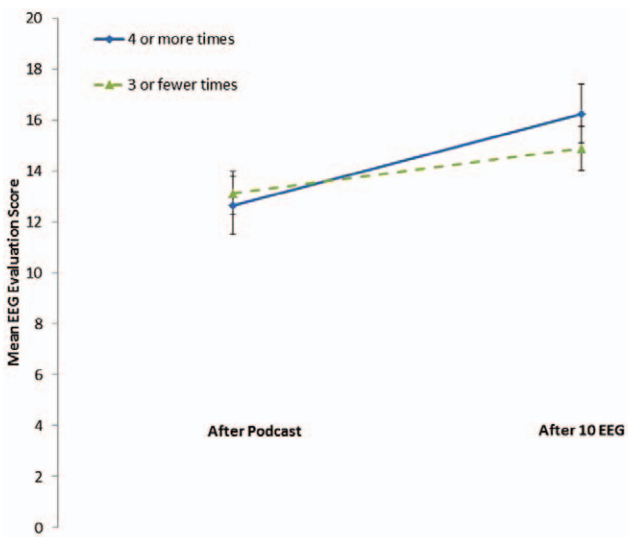

Figure 2. Difference in mean electroencephalogram (EEG) score changes due to prior podcast experience. Those with more prior podcast experience (≥4 times) had greater increases (i.e., steeper slope of the line) in mean EEG evaluation score from after the podcast module to after 10 EEG readings than those with less prior experience (≤3 times) (P for interaction = 0.027). Error bars represent 95% confidence intervals.

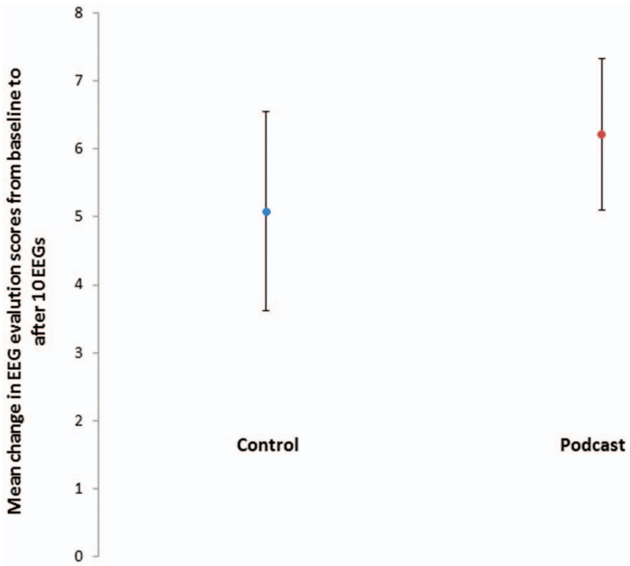

Figure 3. Mean change in electroencephalogram (EEG) scores from baseline and after 10 EEG interpretations between the podcast group and the control group. Error bars represent 95% confidence intervals.

Comparison Between Podcast Module and Standard Didactics as Learning Tools

The baseline EEG evaluation scores of the control group ($n = 24$, mean = 9.83 ± 3.00) did not significantly differ from the podcast group ($n = 33$, mean = 9.36 ± 2.99) ($\beta = 0.75$, SE = 1.04, $P = 0.47$), even after controlling for background characteristics (gender, educational background, and year of assessment). However, there was a small yet significant, difference in mean EEG evaluation scores after 10 EEGs between groups ($\beta = 1.33$, SE = 0.65, $P = 0.05$), after adjusting for background characteristics and baseline EEG evaluation scores. The podcast group displayed greater increases from baseline to after 10 EEGs ($n = 33$, mean change = 6.21 ± 3.07) compared with the control group ($n = 24$, mean change = 5.08 ± 3.45) (Fig. 3).

DISCUSSION

This study examined (1) how access to technology, prior podcast experience, and whether opinions on podcasting were associated with improvement in EEG evaluation after a podcast education module and (2) how this improvement after our podcast module depended on an individual's previous experiences with podcasting. Specifically, those with more prior podcasting experience achieved greater gains in EEG evaluation scores after participating in the podcast module. Additionally, we provide some evidence that our podcast education module, overall, is a successful learning tool in EEG education in comparison to standard didactic training. Finally, results from our survey revealed that medical students and anesthesiology residents overall supported podcasting as a useful, easy to understand educational tool.

Podcasting is currently being used as an anesthesia education resource in several venues. Anesthesia-related medical journals such as *Anesthesia and Analgesia*[4] now use podcasting. To assess the use of podcasting, the top 25 anesthesia-related journals published in the English language as rated by impact factor from Journal Citation Reports® (Thompson Rueters) Science Edition for 2012 were reviewed.[b] Three of those journals use podcasts, as detailed in Table 3; all were ranked 7th or higher by impact factor. Three of the top 5 journals (ranked by 5-year impact factor) report using podcasts (journals listed in Table 3). The 5-year impact factors for these 3 journals range from 3.349 to 5.430.

[b]2012 Journal Citation Reports® Science Edition (Thomas Reuters, 2013). Available at: http://wokinfo.com/products_tools/analytical/jcr/. Accessed May 27, 2014.

Table 3. Anesthesia Journals That Use Podcasts

Journal	Frequency of podcasts	Details of podcast	Link to site
Anesthesia and Analgesia (*Anesth Analg*)	Monthly	Provides discussion of relevant article from the journal, often with the authors themselves providing insight	http://journals.lww.com/anesthesia-analgesia/Pages/podcastepisodes.aspx?podcastid=3
Open Anesthesia	Monthly	TEE of the month Ask the Expert Article of the month A&A Video Summary Virtual Grand Rounds in Obstetric Anesthesia	http://www.openanesthesia.org/OpenAnesthesia.org:MultimediaPlayer#tab=TEE_of_the_month http://www.openanesthesia.org/OpenAnesthesia.org:MultimediaPlayer#tab=Ask_the_Expert http://www.openanesthesia.org/OpenAnesthesia.org:MultimediaPlayer#tab=Article_of_the_Month http://www.openanesthesia.org/OpenAnesthesia.org:MultimediaPlayer#tab=A_26A_Video_Summary http://www.openanesthesia.org/OpenAnesthesia.org:MultimediaPlayer#tab=Virtual_Grand_Rounds_in_Obstetric_Anesthesia
Anesthesiology (*Anesth*)	Monthly	Provides an overview of issue editorials and original studies.	http://journals.lww.com/Anesthesiology/pages/default.aspx
British Journal of Anaesthesia (*Brit J Anaesth*)	Monthly	Provides a free interview podcast with each published issue to keep current you with the latest research.	http://bja.oxfordjournals.org/

As the "Net Generation," born since 1982, matriculate as medical students and residents, we find that they have been raised in an increasingly digital world and, as a result, are comfortable harnessing technology for their own purposes, including for its educational benefits. A survey of 368 preclinical and clinical medical students at a major Australian University[16] revealed that those medical students had a high degree of access to mobile phones, desktop computers, memory sticks, and broadband Internet, with the preclinical students in particular reporting more frequent use of podcasts. The medical students in this group were not homogenous; although between 20% and 40% of students used emerging technologies daily or weekly, a significant portion (30%–50%) were not using them at all.[17]

Factors impacting attitudes toward electronic learning among first-year University of Vienna medical students were analyzed, and several were identified.[18] The significant factors included inexperience with computer- and Web-based training, age of first computer use, and productive use of a computer and the Internet (e.g., e-mail, spreadsheets); gender was not a significant factor. Our results revealed that prior experience with podcasting moderated improvement in EEG evaluation after the podcast education module. Ensuring that there is an appropriate orientation to technologies for the learner lacking familiarity with them may be important in obtaining positive educational outcomes, making this a potential area for future research. Assuming that medical students and trainees have the advanced technology skills for these types of activities may be unfounded, as a national study of medical students in the United Kingdom found that information technology skills of the medical students lagged behind their professional qualifications.[16]

Information and computer technology skills are important, as these technologies will be a requirement of physicians for continuous, lifelong learning to remain current with the rapid growth in medical knowledge[19,20] and to provide optimal evidence-based medicine.[21] These skills also are important for participation in electronic health care delivery. There is evidence that students lacking computer skills at the start of their training often do not obtain them during their clinical years.[22]

In a study of medical students in an obstetrics and gynecology rotation that examined whether distance learning offsite differed from training at the main training base, 13 trainees agreed to participate in a survey of open-ended and quantitative questions.[7] None of the students surveyed had used podcasts for social purposes; 1 student had used podcasts for academic purposes. The obstetrics and gynecology educators were invited to complete a survey; there were 15 respondents. Both the students and educators valued the human interaction with the teachers, preferring face-to-face interaction to distance learning. In contrast, the current study found that >60% of the sample either agreed or strongly agreed that the podcast was preferable to the lecture format, implying the lack of real-time, face-to-face interaction during the podcast content delivery did not detract from its educational benefit. Although seemingly counterintuitive, it could be speculated that the technological comfort level of the participants, as well as their positive rating of the podcast experience, were significant contributors to this finding. This remains an area for further exploration as technological-related educational perceptions are likely to undergo changes with the changing characteristics of new generations of learners. Over time, the learners also may become more technologically homogeneous as a group with regard to podcasting, as it becomes increasingly used, but will show heterogeneity with upcoming new advances as they are incorporated into education. It is also interesting that our podcast opinion summary score did not significantly affect the scores. One explanation would be that in looking at the individual measures that comprised the score, participants were generally comfortable with technology and had a favorable opinion of the podcast module. This sample seems facile with technology and may not have shown the heterogeneity necessary to detect an association.

Basic knowledge can be delivered with podcasts and thus permit or increase the availability of contact time between educators and students to facilitate learning and understanding the application of the knowledge. With the current challenges faced by academic health centers, including fiscal constraints coupled with the decreasing reward for teaching and increasingly heavy commitment to provide care for patients,[23] podcasting, as a mode of delivery of key basic principles, may permit educators to optimize instructional time for students. This model using podcasting for basic knowledge delivery would still allow student-valued learner interactions with instructors and might allow more EEG interpretations that might enhance long-term retention of the material.[24] The model was used in our study for EEG instruction as a podcast presenting basic information followed by instructor interaction interpreting 10 EEGs, thus applying the knowledge learned.

In a recent survey, the majority of Canadian medical residents who responded to an electronic survey used podcasts.[5] Of those who used podcasts, 67% of residents watched them for up to at least 1 hour a week, whereas others watched them for 4 to 6 hours per week, and approximately 1% reported no access to a portable player.[5] One criticism of this study was that it was Web based and may have resulted in preferentially selecting individuals who are technologically advanced. This has been a criticism of some of the successful Web-based training studies, which have included occurring in specialized settings (e.g., a University campus or Web-based courses) or performed in specialties where there is a higher likelihood of involving professionals with more advanced computer/technology background.[25–28]

Instructional models should form the foundation for educational delivery that harnesses technology and its incorporation in to the educational mission. There are potential benefits and limitations of the application of technology in these circumstances. One of the challenges for evaluating its use is that it is becoming increasingly more difficult to locate individuals who have no technology exposure. It is also virtually impossible to find a group that has not been exposed to traditional education methods. One of the challenges is that technological innovation happens so rapidly that established organizational bodies (e.g., Accreditation Council for Graduate Medical Education) find it challenging to incorporate these technological innovations into long-term educational strategies.

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Name: Terrie Vasilopoulos, PhD.
Contribution: This author is a statistician and helped in the design of the statistical analysis for the study, and in the writing of the manuscript.
Attestation: Terrie Vasilopoulos has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.
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Name: Destiny F. Chau, MD.
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Name: Meriem Bensalem-Owen, MD.
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