

An Assessment of Pathology Resident Access to and Use of Technology

A Nationwide Survey

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• **Context.**—Current technologies including digital slide scanners and handheld devices can revolutionize clinical practice and pathology graduate medical education (GME). The extent to which these technologies are used in pathology GME is unknown.

Objectives.—To determine the types of technologies used, usage amount, and how they are integrated into pathology residency/fellowship programs nationwide.

Design.—A 40-question online survey for residents/fellows was developed and administered via the Research Electronic Data Capture System after institutional review board approval.

Results.—Fifty-two program directors (37%) gave permission for participation. One-hundred seventy-one responses were received (18% response rate). Most respondents have access to personal technology (laptop = 78% [134 of 171]), smartphone = 81% [139 of 171], tablet = 49% [84 of 171]), and Web-based digital slide collections (82%, 141 of 171). Few residents are provided electronic devices by their programs (laptop = 22% [38 of

171], smartphone = 0.5% [1 of 171], and tablet = 12% [21 of 171]). Fifty-nine percent have access to digital slide scanners, 33% have access to a program-created database of digitized slides, and 52% use telepathology. Fifteen percent have access to asynchronous learning. Of those with access to video-recorded conferences, 89% review them. Program size was significantly positively correlated with resident access to program-provided laptops ($P = .02$) and tablets ($P < .001$), digital slide scanners ($P = .01$), and telepathology ($P = .001$). Of all devices, program-provided laptops are used most for professional work (60.5% use this device for more than 5 hours per day).

Conclusions.—Most residents report access to multiple types of innovative technology, but incorporation of these tools within pathology training programs is highly variable. Opportunities for incorporating innovative technologies exist and could be further explored.

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The body of medical information is rapidly expanding, and most of it is now digitized.¹ This converges with the emergence of novel instructional technologies, providing opportunities to use technology to support learning.^{1,2} Technology has become ubiquitous in daily living, in the practice of medicine, and is establishing a presence in medical education.³ Mobile devices such as smartphones, tablets, and laptops are leveraged as repositories for digital

learning resources and as interactive learning tools using social media.^{4–11}

Not only has technology changed, but so has the generation of learners in medical education. The current generation, “Net Generation,” “Generation Y,” or “the Millennials,” includes individuals born between 1982 and 1991. Exposed to computers and the Internet since childhood, they are “native speakers” of the digital language.¹² Some have suggested that the “net generation” learns in fundamentally different ways from previous generations.^{13–15} Learning from reading and listening to lectures is not highly valued by millennials.¹⁶ Rather, millennials want learning to be interactive, creative, and fun.¹⁷ To that end, Eckleberry-Hunt and Tucciarone¹⁸ recommend that graduate medical education (GME) educators make interactive teaching with technology an area of focus. Different approaches and shifts in practices are necessary to efficiently educate current learners,³ such as including interactive, socially engaging group discussion and elements of hands-on learning.⁷

Pathologists are physicians central to all patient care and medical decision making. Daily, pathologists use technology to deliver high-quality patient care. As such, pathologists have unique opportunities to incorporate technology in

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Table 1. Demographic Data

Program Director Response	Responding Yes	Responding No	No Response	Total Count (%)	
Program size, count (%)					
1–8	5 (31.3)	0 (0.0)	11 (68.8)	16 (11.4)	
9–16	25 (37.9)	3 (4.6)	38 (57.6)	66 (46.8)	
17–24	16 (41.0)	0 (0.0)	23 (59.0)	39 (27.7)	
25+	6 (30.0)	2 (10.0)	12 (60.0)	20 (14.2)	
Total count (%)	52 (36.9)	5 (3.5)	84 (59.6)	141	
	Program Size				
Respondents' Demographic Data	1–8	9–16	17–24	25+	Total Count (%)
PGY level, count (%)					
1	4 (8.9)	15 (33.3)	19 (42.2)	7 (15.6)	45 (26.3)
2	1 (2.7)	18 (48.7)	13 (35.1)	5 (13.5)	37 (21.6)
3	1 (2.9)	11 (31.4)	16 (45.7)	7 (20.0)	35 (20.5)
4	4 (10.0)	18 (45.0)	15 (37.5)	3 (7.5)	40 (23.4)
5–6	0 (0.0)	7 (50.0)	5 (35.7)	2 (14.3)	14 (8.2)
Total count (%)	10 (5.8)	69 (40.4)	68 (39.8)	24 (14.0)	171

Abbreviation: PGY, postgraduate year.

GME. However, the extent of technology utilization in pathology GME is unknown. The purpose of this study is to determine the types of technologies used, usage amount, and how they are integrated into anatomic and clinical pathology GME programs nationwide.

METHODS

An original electronic questionnaire was created by using the research electronic data capture system (REDCap, Vanderbilt University, Nashville, Tennessee), which is a secure, Web-based application for building and managing online surveys and databases.¹⁹ No comparable questionnaire currently exists. Following review by a panel of content experts including residents, program director, bioinformatician, statistician, survey designer, medical educator, and pathology faculty, a final questionnaire of up to 40 items was created; the number of questions for each respondent was variable depending upon self-reported device ownership. Where applicable, a Likert-type response scale was used: (1) not at all; (2) slightly disinterested; (3) neutral; (4) somewhat interested; and (5) very interested.

A comprehensive list of anatomic and clinical pathology residency programs within the United States, with their email addresses and phone numbers, was compiled by using a combination of the FREIDA Online Web site (<https://freida.ama-assn.org/>; accessed January 24, 2014), individual program Web sites, and the College of American Pathologists (CAP) membership directory. At the time of survey development (January–February 2014), a total of 141 programs were identified and individual approval for resident and fellow participation was sought from program directors before distribution. The questionnaire was distributed by 1 of 2 methods depending upon program director preference: (1) individual email link via REDCap survey administrator or (2) general email link. The survey was open for 17 days (February 11, 2014–February 28, 2014).

Data were collected by using Duke University Medical Center's (Durham, North Carolina) REDCap survey tool. Only the research primary investigators and coordinator had access to the data. The research coordinator aggregated the data before distributing it to the research primary investigators in order to maintain response anonymity. All numerical data were entered and analyzed by using the Statistical Package for Social Sciences version 21.0 (IBM Corp, Armonk, New York) and the statistical analysis system version 9.3 (SAS Institute, Cary, North Carolina). The association of postgraduate year (PGY) level with ownership of and access to technology was evaluated by using the χ^2 test with 4 degrees of freedom. The

association of program size with access to technology was evaluated as an ordinal variable with 1 degree of freedom χ^2 test.

This study was approved by the Duke University Hospital Institutional Review Board.

RESULTS

Response Rate

Fifty-two of 141 pathology residency program directors (37%) permitted trainee participation. Table 1 shows program director response data versus program size. Program directors who declined participation cited that participation is not allowed per their designated institutional official (1 program), poor timing owing to internal and Accreditation Council for Graduate Medical Education surveys (2 programs), and no reason (2 programs). One-hundred seventy-one individual responses were received (18% response rate) of a possible 950 residents and fellows in the 52 programs willing to participate. Table 1 also contains respondents' demographic data.

Personal Access to Technology

Most respondents own personal devices (laptop = 78% [134 of 171], smartphone = 81% [139 of 171], and tablet = 49% [84 of 171]). Ninety-three percent (159 of 171) have access to at least 1 of the 6 devices queried (program-provided laptop, tablet, and smartphone; and personal laptop, tablet, and smartphone), 83% (142 of 171) have access to 2 or more devices, and 58% (100 of 171) have access to 3 or more devices. Detailed results of trainee access to personal devices by PGY level are shown in Table 2.

Most respondents (82%, 141 of 171) reported accessing Web-based digital slide databases such as the California Tumor Tissue Registry, The Rosai Collection, the College of American Pathologists case of the month, and the United States and Canadian Academy of Pathology virtual slide box, among others. Seventy percent (98 of 141) reported using the slide sets for less than 1 hour per day; 26% (36 of 141) reported that they use the virtual slide sets for 1 to 2 hours per day.

Program-Provided Access to Technology

Detailed results of respondent access to program-provided technology are shown in Table 3. When given

Table 2. Resident Access to Personal Devices by PGY Level

PGY Level	Count	%	Personal Laptop Ownership, Count (%)		Personal Tablet Ownership, Count (%)		Personal Smartphone Ownership, Count (%)	
			No	Yes	No	Yes	No	Yes
1	45	26.3	4 (8.9)	41 (91.1)	23 (51.1)	22 (48.9)	6 (13.3)	39 (86.7)
2	37	21.6	14 (37.8)	23 (62.2)	21 (56.8)	17 (43.2)	10 (27.0)	27 (73.0)
3	35	20.5	7 (20.0)	28 (80.0)	18 (51.4)	17 (48.6)	8 (22.9)	27 (77.1)
4	40	23.4	8 (20.0)	32 (80.0)	20 (50.0)	20 (50.0)	7 (17.5)	33 (82.5)
5-6	14	8.2	4 (28.6)	10 (71.4)	5 (35.7)	9 (64.3)	1 (7.1)	13 (92.9)
Total	171	100.0	37 (21.6)	134 (78.4)	87 (50.9)	84 (49.1)	32 (18.7)	139 (81.3)
<i>P</i> value			.03		.77		.38	

Abbreviation: PGY, postgraduate year.

a choice, most reported that they would prefer a tablet (52%, 89 of 171) be provided by their program versus a laptop (37%, 64 of 171) or a smartphone (11%, 18 of 171). Overall, respondents were either slightly or very interested in tablets (75%, 128 of 171), smartphones (48%, 82 of 171), and laptops (63%, 108 of 171) being provided by their training program. Few program-provided laptops (11%, 4 of 36) and tablets (10%, 2 of 20) were preloaded with pathology e-books. None of the program-provided tablets were preloaded with educational pathology applications. Fifty-two percent (87 of 168) have access to telepathology, and uses included frozen sections (33%, 51 of 157), frozen section consultations (24%, 37 of 157), general consults (9%, 14 of 157), fine-needle aspiration biopsy rapid on-site assessment (16%, 25 of 157), resident education (18%, 27 of 157), and others (2%, 3 of 157). Access to telepathology was positively correlated with program size ($P = .001$). Regarding whole slide imaging (WSI), 33% (55 of 167) of respondents reported having access to a program-created database of slides despite 59% (99 of 169) with access to a digital slide scanner. Most (87%, 48 of 55) of those with access used them for less than 1 hour per day. Within the cohort without access to a program-created database of slides, 58% (65 of 112) said that if they had access they expected daily use to be between 1 to 2 hours per day, while 37% (41 of 112) said they expected they would use it for less than 1 hour per day. Access to WSI was positively correlated with program size ($P = .01$). Of those with video-recorded conferences (27 of 170), 93% (25 of 27) had access to view the videos asynchronously and 63% (15 of 24) reported viewing them for up to 1 hour per day, while 25% (6 of 24) reported viewing the conferences for 1 to 2 hours per day. Those without access expected they would view video-recorded conferences for less than 1 hour (53%, 75 of 142) or 1 to 2 hours (20%, 29 of 142) per day if they did have access.

Utilization of Devices

Figure 1 compares laptop and tablet utilization. Program-provided laptops are more frequently used for accessing electronic medical records (EMRs; 92%, 35 of 38), writing pathology reports (92%, 35 of 38), and PubMed searches (87%, 33 of 38) than personal laptops (59% [79 of 134], 36% [48 of 134], and 78% [104 of 134], respectively). Utilization for scholarly effort is similar for both program-provided laptops (84%, 32 of 38) and personal laptops (82%, 110 of 134). Compared to laptops (program-provided and person-

al), tablets are used less frequently for scholarly efforts (43%, 45 of 105). However, educational applications, which are unavailable on laptops, were used by both those with a personal (42%, 35 of 84) or program-provided (43%, 9 of 21) tablet.

The most common program-provided and personal smartphone uses were email (95%, 133 of 140), phone calls (84%, 118 of 140), and texting (81%, 114 of 140), though only 1 respondent reported receiving a program-provided smartphone. Overall, smartphones are reported to be used mainly for communication, organization of contacts (46%, 64 of 140), calendars/scheduling (72%, 101 of 140), and nonspecific Internet searches (64%, 89 of 140). They are rarely used for accessing EMRs (10%, 14 of 140), writing pathology reports (1%, 2 of 140), scholarly efforts (22%, 32 of 140), or PubMed searches (27%, 38 of 140).

Figure 2 compares laptop and tablet utilization for professional work. Many respondents reported using their personal electronic devices for professional work: Seventy-five percent (100 of 134) used personal laptops for 1 hour per day or more, while 56.5% (79 of 139) used personal smartphones for 1 hour per day or more and 51.8% (43 of 84) used personal tablets for 1 hour per day or more.

DISCUSSION

This study investigated types of and utilization of innovative technology in pathology GME nationwide. No prior study has assessed innovative technology in GME, regardless of specialty.

Pathology residents have access to multiple innovative technologies, including portable devices (laptop, tablet, and smartphone), telepathology, digital slide scanners, and online conferences. Access to portable devices is generally provided by the residents themselves. Many (58%) own 3 or more personal devices. Provision of portable devices by a program is rare and correlates with program size, possibly because larger programs have more abundant resources than smaller programs. When given a choice, most pathology respondents prefer a program-provided tablet. Interestingly, 49% report personal ownership of a tablet, and it is possible that they desire what they do not possess, despite the possible advantages or disadvantages of a given device.

Portable devices are used for email, Internet searches, scholarly efforts, PubMed searches, accessing the EMR, calendar/scheduling, reading e-books, writing pathology reports, contact organization, and photography. Smartphones are essentially used for communication functions,

Table 3. Access to Innovative Technologic Resources by Program Size

Program size	Access to Telepathology, Count (%)		Access to Digital Slide Scanner, Count (%)		Access to Video-Recorded Conferences, Count (%)		Program-Provided Laptop, Count (%)		Program-Provided Tablet, Count (%)		Total Count (%)
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	
1-8	9 (90.0)	1 (10.0)	9 (90.0)	1 (10.0)	0 (0.0)	1 (100.0)	8 (80.0)	2 (20.0)	1 (3.7)	10 (5.8)	10 (5.8)
9-16	38 (55.9)	30 (44.1)	28 (40.6)	41 (59.4)	1 (25.0)	3 (75.0)	56 (81.2)	13 (18.8)	4 (14.8)	69 (40.4)	69 (40.4)
17-24	22 (32.4)	46 (67.7)	25 (37.9)	41 (62.1)	0 (0.0)	11 (100.0)	46 (67.7)	22 (32.4)	11 (40.7)	68 (39.8)	68 (39.8)
25+	12 (54.6)	10 (45.5)	8 (33.3)	16 (66.7)	1 (9.1)	10 (90.9)	23 (95.8)	1 (4.2)	11 (40.7)	24 (14.0)	24 (14.0)
Total	81 (47.9)	87 (51.8)	70 (41.4)	99 (58.6)	2 (7.4)	25 (92.6)	133 (77.8)	38 (22.2)	27^c	171	171
<i>P</i> value		.001		.01		.34		.02			<.001

^a Missing 3 responses.

^b Missing 2 responses.

^c Only residents with "Yes" response to video-recorded conferences.

while laptops and tablets have broader functionality. Laptops are useful for email, writing pathology reports, scholarly activity, and accessing the EMR, while tablets are useful for reading e-books and have limited utility for writing pathology reports and accessing the EMR. These data suggest that laptops may be more useful than tablets in the pathology clinical learning environment. Thus, laptops may yield a high return on investment for program directors. Additional benefits of a program-provided laptop include the ability to encrypt the device for secure mobile access to patient and research data. Device cost is a disadvantage, although programs may be able to negotiate lower prices when buying multiple units.

Telepathology and digital slides, once considered futuristic, are increasingly incorporated into daily practice. Telepathology is the practice of pathology at a distance, using technology to directly view a specimen, rather than a microscope.²⁰ Whole slide imaging uses digital slide scanners to scan glass slides, creating digital slides,²¹ and can be used for education,^{4,5,22-31} consultations, and clinical diagnostics.³² Further, WSI is increasingly used for assessment on the American Board of Pathology certification examination.^{23,24,26,28,33} Thus, access to and specific instruction in telepathology and digital pathology are becoming progressively necessary.³¹ Implementation of these technologies is costly and this can be prohibitive. In this study, 52% reported having telepathology, and 59% have access to WSI. Program size was positively correlated with increased access to both telepathology ($P = .001$) and WSI ($P = .01$), likely due to resource constraints in smaller training programs.

Asynchronous learning is not widely used within pathology GME. Larger programs tended to have video-recorded conferences, compared to smaller programs, possibly owing to resource limitations. Larger programs may also have off-site residents, necessitating video-recording or streaming their conferences.

A few respondents reported provision of applications (Apps) and/or e-books downloaded or preloaded onto personal or program-provided smartphones, laptops, and tablets. This is likely partially due to a distinct lack of available educational pathology applications. Additionally, most academic institutions provide e-book access through their university libraries, circumventing the need for individual versions downloaded onto mobile devices.

The survey response rate was 18%, including 171 responses from up to 52 residency programs. Eighteen program directors were given general links to forward to their trainees rather than individual links, precluding confirmation of the exact number of respondents who received the link to the questionnaire. Therefore, the response rate reported herein may actually be higher. Low response rates within the smallest and largest program sizes (1-8 and >25) are a limitation of the study and prevented further statistical analysis. However, the distribution of responses by program size is comparable to that of actual distribution of programs by program size (see Table 1). Evaluation of smartphone access, video-recorded conferences, program-provided laptops, and tablets was limited by small sample size. Only 1 respondent reported receiving a program-provided smartphone, thus no additional conclusions can be drawn.

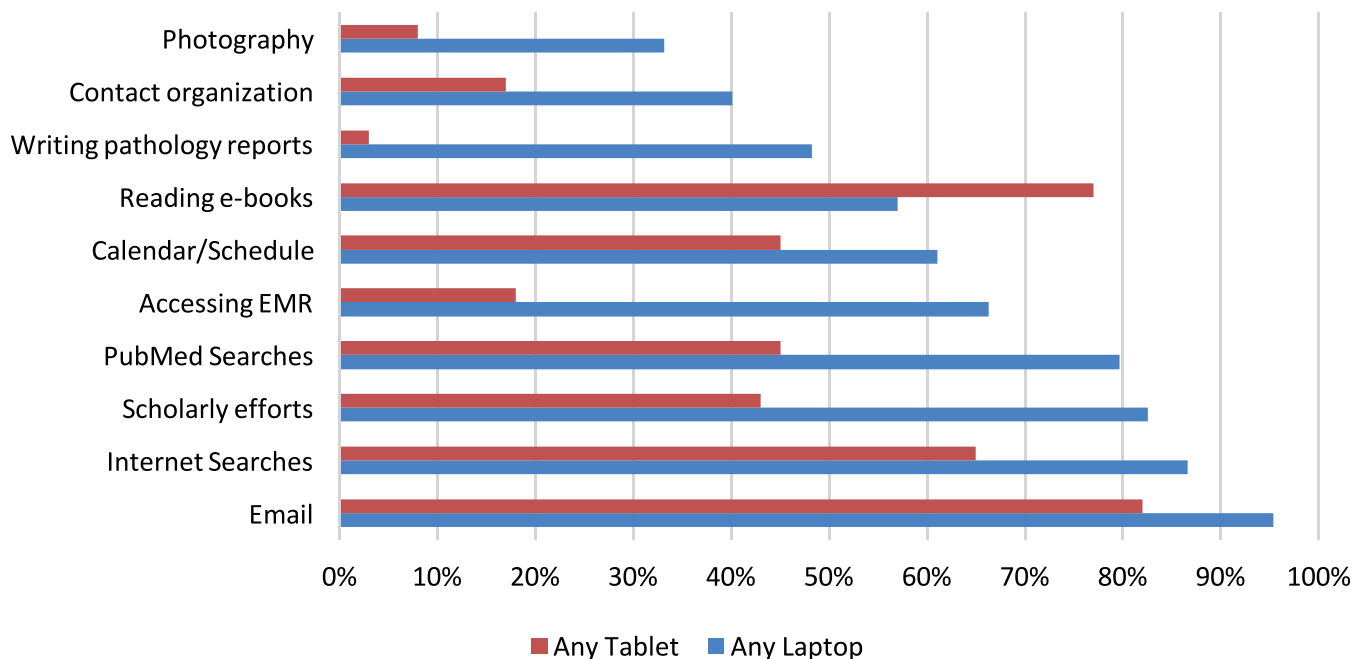


Figure 1. Laptop versus tablet uses. Abbreviation: EMR, electronic medical record.

CONCLUSIONS

Access to and utilization of technology in pathology GME is increasingly available and will eventually become a necessity. Millennial learners are well versed in the use and application of technology and desire learning opportunities that incorporate these tools. Access to personal devices is unprecedented and will only continue to

expand.^{34,35} In pathology GME, program-provided laptops, telepathology, and WSI are becoming an integral part of education and may eventually be considered as core requirements. Exposure to these technologies allows residents to progress in the systems-based practice competency for technology assessment and for informatics,³⁶ preparing today's residents for the future of pathology.

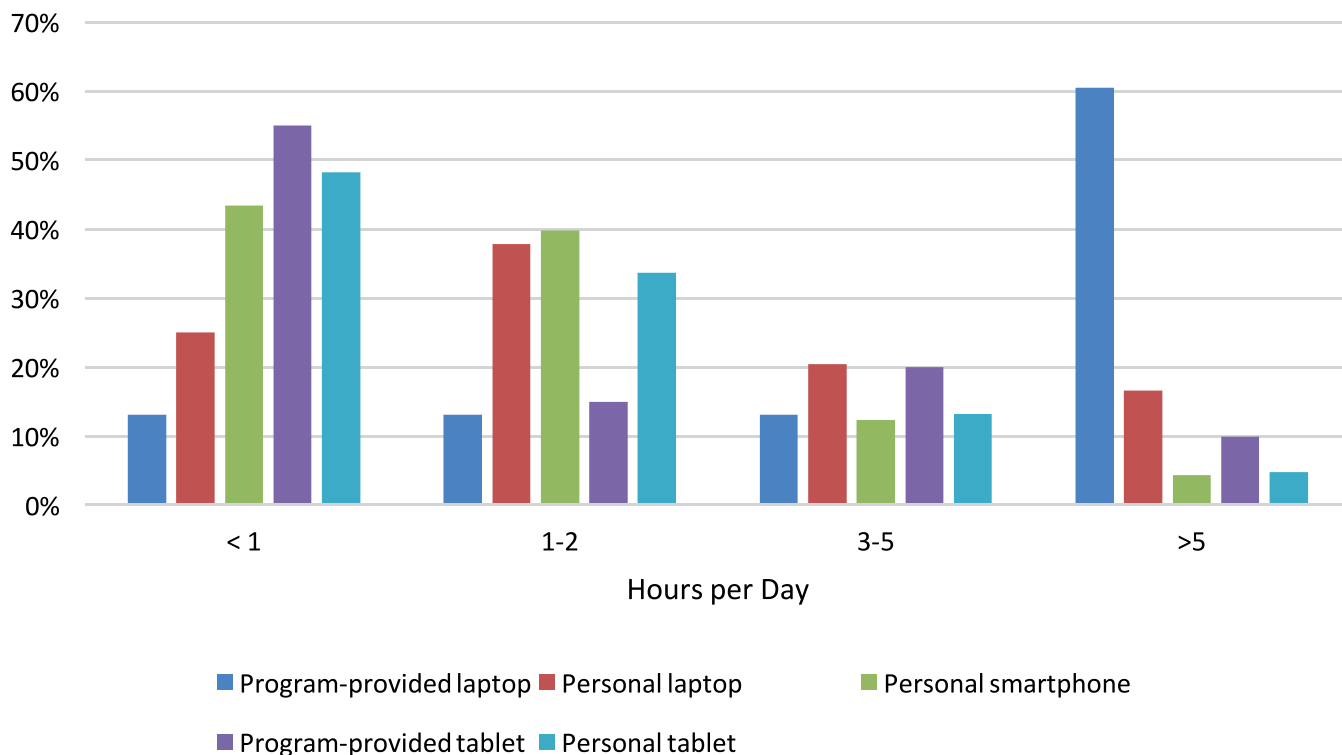


Figure 2. Utilization of electronic devices for professional work.

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