Received: 15 October 2021 | Revised: 15 December 2021 | Accepted: 17 December 2021

DOI: 10.1096/fba.2021-00124

FASEB BioAdvances WILEY

RESEARCH ARTICLE

Brave new E-world: Medical students' preferences for and usage of electronic learning resources during two different phases of their education

Erin Finn[1] | **Fred Ayres**[1] | **Stephen Goldberg**[1,2] | **Michael Hortsch**[3,4]

[1]University of Michigan Medical School, Ann Arbor, Michigan, USA

[2]Department of Anesthesiology, University of California Irvine Medical Center, Irvine, California, USA

[3]Department of Cell and Developmental Biology, University of Michigan Medical School, Ann Arbor, Michigan, USA

[4]Department of Learning Health Sciences, University of Michigan Medical School, Ann Arbor, Michigan, USA

Correspondence
Michael Hortsch, Department of Cell and Developmental Biology, University of Michigan Medical School, Ann Arbor, MI, USA.
Email: hortsch@umich.edu

Funding information
Monetary incentives to promote survey responses for this study were provided from Dr. Hortsch's discretionary faculty account.

Abstract

E-learning strategies have become an important part of biomedical education. However, why and how medical students select hardware tools and software formats during their preclinical education has not been sufficiently evaluated. These aspects should be considered when designing or offering new e-learning modalities to learners. Two medical school classes at a major US medical school were surveyed about their use of e-learning resources during their first year of medical school or their preparation for their first licensing examination (USMLE® Step 1), respectively. Their responses were analyzed for patterns and significant changes. Students' answers indicated that computers and tablets were considered the most important hardware devices to support students' learning. During the first year, students often preferred resources that were tailored to the specific courses in their curriculum. In contrast, some preferences changed when students prepared for the USMLE Step 1, with students shifting almost exclusively to a solitary learning strategy using commercial e-learning resources. Across all phases of medical school education queried, peer advice was the major determinant influencing e-learning resource selection with faculty only playing a minor role. Videos were the most popular e-learning modality, and students cited efficient acquisition of knowledge and preparation for examinations as major reasons for e-learning tool utilization. These factors should be considered when offering e-learning resources to medical students during different phases of their preclinical training.

KEYWORDS

e-learning, learning resources, preclinical medical education, technology-enhanced learning, user preferences, USMLE

Abbreviations: e-learning, electronic learning; UMMS, University of Michigan Medical School; USMLE®, United States Medical Licensing Examination.

1 | INTRODUCTION

As modern medicine relies increasingly on new technologies for diagnosis and treatment, so does the education of new medical professionals.[1–3] Electronic learning/e-learning, mobile learning, and digital learning each encompasses education using electronic devices and media.[4] Different electronic devices, including computers, computer tablets, and smartphones, are being used by medical learners for their education and are also increasingly integrated into medical curricula.[2,3] To match this growing utilization of electronic devices, a wide range of electronic media has concurrently been developed. These include video recording, podcasts, mobile applications, website, databanks, and more.[2,3] They provide a wide array of educational opportunities and can serve different purposes. However, their true educational value is still the topic of ongoing debate.[5–7]

In addition to e-learning tools developed by medical educators to serve specific courses or institutional learning objectives, a growing number of free and commercial e-learning resources are also being offered to medical students.[8–10] These often support specific standardized phases of medical education, such as professional licensing assessments like the United States Medical Licensing Examination Step 1 (USMLE® Step 1). In combination with other co-variants, some studies have indicated that the use of these commercial learning resources is correlated with improved performance on these examinations.[9,11] In contrast, other studies have found that general academic medical school performance is a better predictor for USMLE Step 1 performance and that the use of commercial resources does not always results in better scores.[12–14]

The current generation of medical students grew up with computers and electronic media and feels comfortable using them.[15,16] Conversely, many current medical educators were introduced to electronic devices later in their careers and are often unsure which e-learning resources to use and how these resources support intended learning objectives.[17–19] This generational gap between learners and teachers can be a roadblock for the introduction of e-learning resources and their optimal use. A better understanding of how students select and integrate these tools into their learning is an important factor for their successful adoption and for complementing traditional education strategies. Unfortunately, little is known about how students choose e-learning tools and for which aspects of the learning process they are used.[20–22] Peer recommendation has been suspected as an important factor, but evidence remains scarce.[23,24]

1.1 | Research aims

The working hypotheses tested by the research reported in this manuscript assumed that medical students mostly select e-learning resources based on peer advice and that different e-learning tools are chosen and used by medical students at different times during their medical school experience. The study asked medical students at a major US medical school about their use of e-learning devices and resources during two phases of their undergraduate medical education, their first year of medical school (M1) and in their third year (M3) while preparing for the USMLE Step 1. Students' answers revealed which e-learning resources they favored, how their choices were made, and for which phases of the learning process these tools were used. By exploring these questions, the ultimate purpose of this study was to help medical and other educators optimize their use of e-learning resources.

2 | METHODS

2.1 | Curricular structure at the University of Michigan Medical School

The University of Michigan Medical School (UMMS) is a large, public research institution that offers a 4-year medical curriculum awarding an M.D. degree.[25] Each year about 170–180 students matriculate into the program. Preclinical education consists of six integrated organ-based blocks that are concentrated in the first year (M1). Medical students enter their clinical rotations in their M2 year, which is usually immediately followed by USMLE Step 1 preparation in their M3 year. However, this timetable is flexible, and some students take the USMLE Step 1 at a later timepoint.

2.2 | Demographic and academic performance data of the student sampling groups

Two UMMS medical school classes were surveyed about their use of traditional and e-learning resources during the M1 year or in preparation for USMLE Step 1. The M1 class had 180 students (40% male and 60% female) who started their M1 year in 2019. Due to the COVID-19 pandemic, all M1 instruction was converted to an online format starting in March 2020. Most members of the M3 class received their M1 education in the 2017–2018 academic year; 43.7% were male and 56.3% were female. The academic qualifications of both surveyed classes upon entering medical school were almost identical. The total and the science GPA for the M1 class were 3.78 ± 0.17 and 3.72 ± 0.23 and for the M3 class were 3.77 ± 0.2 and 3.71 ± 0.27.

2.3 | Surveys of UMMS students

In April 2020, all 197 members of the M3 class were invited by email to participate in an online survey (Appendix S1). This included 16 students (13.4%) who were not originally members of this class and had delayed taking the USMLE Step 1. Two students responded that they had not taken the USMLE Step 1 as their date was canceled by the COVID-19 pandemic. Because they had completed their preparation, their answers were included. In June 2020, the M1 class of the 2019–2020 matriculation year was invited by email to participate in a similar survey (Appendix S2). Informed consent and details about the project and confidentiality protection were part of the survey introduction (Appendices S1 and S2). Both surveys' deadlines were about 1 month after the initial invitation. Participation was voluntary and incentivized by three $70 USD cash prizes per class that were awarded by random drawing. The surveys were constructed using the Qualtrics online survey software (Qualtrics). The survey items were drafted by the authors and underwent a careful review, testing, as well as revision process by the student authors. Only M3 students were asked questions about their USMLE Step 1 preparation. Survey results were stored on core-managed, password-protected computers that were accessible only to the senior author of the study (M.H.). Prior to data analysis, he de-identified all responses.

2.4 | Statistical analysis

SAS Version 9.4 (SAS Institute) was used for data analysis. Chi-square or Fisher exact testing was used to compare differences in distribution of the outcome variables. Fisher exact testing was used when a count for a given outcome had a value of <5. Effect sizes were calculated as odds ratios. The M1 and M3 classes were treated as independent, mutually exclusive groups. An original threshold for significance of $p < 0.05$ was assumed. As primary outcomes of interest were multiple, the Bonferroni correction was used to account for multiple comparisons and to reduce the risk of type 1 errors. The resulting *p*-values of significance are listed under each table.

3 | RESULTS

3.1 | Survey responses

After eliminating incomplete and duplicated survey responses, 108 complete answer sets were collected from the M1 and 119 from the M3 class, with a survey response rate of 60.0% and 60.4%, respectively.

3.2 | Preference for hardware devices

Very few students (≤10 in each class) named traditional writing utensils, paper textbooks, or course/lecture handouts as their most favorite hardware learning device (Table 1). Although most students owned a smartphone, very few survey participants considered this type of device as their primary learning instrument. Laptop/desktop computers and computer tablets were the most preferred hardware tools in both classes (Table 1). When the preference for laptop/desktop computers versus computer tablets was analyzed in more detail, a statistically significant increase of computer tablet use became apparent among the M1 students compared to the M3 class with a corresponding decrease of laptop/desktop computer use (Table 1).

3.3 | Preference for e-learning formats/software

When asked about their most favorite general software modality, videos (from YouTube and several commercial vendors) and commercial education websites (e.g., Osmosis, UWorld, and others) were the most preferred general software modalities for both classes of students (Table 1). Mobile apps and social media, however, were each named by only one M3 student (Table 1). No significant differences were found when comparing the two classes.

Table 2 displays students' answers to which specific e-learning resources they regularly used during the M1 year or for USLME Step 1 preparation. Among the M1 class members, lecture handouts, and video recordings were the most popular resources. However, very few M3 students reported reusing these materials for their USMLE Step 1 preparation, representing a highly significant decrease compared to M1 students. In addition, M1 students indicated using several commercial medical e-learning tools. Specifically, Anki, Osmosis, and SketchyMedical were mentioned by more than 50% of responding M1 students. When M3 students were asked which commercial e-learning resources they used during their USMLE Step 1 preparation, a similar pattern emerged with some resources seeing a significant increase when compared to the M1 class (Pathoma and UWorld) and others experiencing a significant decrease (Boards and Beyond® and Osmosis).

3.4 | Money spent on study resources

Both student groups were asked how much of their own money they spent on additional learning resources

TABLE 1 Medical students' (M1 vs. M3 class) favorite general hardware and software modalities

Which type of device/material is your most used, most favorite for learning in medical school?		M1 class % ($N = 108$)	M3 class % ($N = 119$)	Statistical analysis (chi-square or [a]Fisher's exact test) *p*-value (odds ratio to be associated with the M3 class)
Hardware	Paper and traditional writing utensils	8.3 (9)	6.7 (8)	0.65 (0.79)
	Books/textbooks/review books (paper version)	0.0 (0)	8.4 (10)	[a]0.0018* (infinite)
	Books/textbooks/review books (electronic version)	1.9 (2)	1.7 (2)	[a]1 (0.91)
	Course/lecture handouts	6.5 (7)	3.4 (4)	[a]0.36 (0.50)
	Smartphone	0.9 (1)	2.5 (3)	[a]0.62 (2.77)
	Computer tablet	38.9 (42)	11.8 (14)	<0.0001* (0.21)
	Laptop or desktop computer	42.6 (46)	62.2 (74)	0.0031* (2.22)
	Other (Please fill in)	0.9 (1)	3.4 (4)	[a]0.37 (3.72)
	Sum of computer tablet, laptop, and desktop computer	81.5 (88)	74.0 (88)	0.17 (0.65)
Software	I do not use any of the below e-learning modalities	1.9 (2)	0.0 (0)	[a]0.23 (0)
	E-books/PDFs/PowerPoint files	16.7 (18)	6.7 (8)	0.022 (0.36)
	Non-commercial educational websites (e.g., PubMed, Michigan Histology website etc.)	4.6 (5)	0.8 (1)	[a]0.1 (0.17)
	Commercial educational websites (e.g., Osmosis, Qbank, Firecracker®, etc.)	19.4 (21)	31.9 (38)	0.032 (1.94)
	Mobile apps	0.0 (0)	0.8 (1)	[a]1 (infinite)
	Computer apps (Anki etc.)	15.7 (17)	15.1 (18)	0.9 (0.95)
	Social media (Reddit, Twitter, Facebook, LinkedIn, etc.)	0.0 (0)	0.8 (1)	[a]1 (infinite)
	Videos (YouTube, Boards, and Beyond®, Pathoma, SketchyMedical, etc.)	39.8 (43)	38.7 (46)	0.86 (0.95)
	Other (Please fill in which)	1.9 (2)	5.0 (6)	[a]0.29 (2.84)

[a]Fisher's exact test.

*Bonferroni adjusted *p*-value of significance <0.0056.

TABLE 2 Use of free and commercial e-learning resources by M1 and M3 students

	Which supplemental e-learning resources did you regularly use during the M1 year? (Select all that apply) M1 class % (*N* = 108)	Which supplemental e-learning resources did you use regularly for the USMLE® Step 1 preparation? (Select all that apply) M3 class % (*N* = 119)	Statistical analysis (chi-square or [a]Fisher's exact test) M1 vs. M3 *p*-value (odds ratio to be associated with USMLE Step 1 preparation)
I did not use any of the below learning resources	0.0 (0)	0.0 (0)	NA
M1 lecture handouts (usually PowerPoint or PDF files)	89.8 (97)	0.0 (0)	[a]<0.0001* (0)
M1 lecture video recordings	87.0 (94)	1.7 (2)	[a]<0.0001* (0.0025)
SecondLook™ mobile apps	64.8 (70)	1.7 (2)	[a]<0.0001* (0.0093)
Amboss	22.2 (24)	10.1 (12)	0.012 (0.39)
Anki	59.3 (64)	47.1 (56)	0.066 (0.61)
Boards and Beyond®	44.4 (48)	17.6 (21)	<0.0001* (0.0.027)
Firecracker®	0.0 (0)	0.0 (0)	NA
Goljan audio podcasts	5.6 (6)	15.1 (18)	0.029 (3.03)
Lecturio	0.9 (1)	0.0 (0)	[a]0.48 (0)
MD Cases	0.0 (0)	0.0 (0)	NA
MEDBULLETS	2.8 (3)	0.8 (1)	[a]0.35 (0.30)
Osmosis	51.9 (56)	10.9 (13)	<0.0001* (0.11)
Pathoma	29.6 (32)	82.4 (98)	<0.0001* (11.08)
PHYSEO	0.9 (1)	0.0 (0)	[a]0.48 (0)
Picmonic®	0.9 (1)	5.9 (7)	[a]0.068 (6.69)
SketchyMedical	63.9 (69)	73.9 (88)	0.1 (1.60)
USMLE-Rx	12.0 (13)	14.3 (17)	0.62 (1.22)
UWorld	1.9 (2)	96.6 (115)	[a]<0.0001* (1523.75)
Other (Please state which)	8.3 (9)	8.4 (10)	0.98 (1.01)

Abbreviation: NA, not applicable.

[a] Fisher's exact test.

* Bonferroni adjusted *p*-value of significance <0.0025.

(excluding tuition and electronic hardware devices, but including books, e-learning tools, and professional tutoring services). The results displayed in Figure 1 indicate that M3 students spent significantly more money to prepare for the USMLE Step 1 than M1 students during their M1 year (Fisher exact test *p*-value of <0.0001). More than 20% of M1 students reported that they did not spend any money on the purchase of additional learning resources or support, whereas all M3 students indicated that they spent at least some of their own money.

3.5 | Origins of e-learning resource recommendations

Another set of questions asked students who recommended their favorite M1/USMLE Step 1 e-learning resource to them or how they found the tool. About 62% of M1 and 78.2% of M3 students named other medical students as the main influencing factor (Table 3). There were some significant differences between the two sets of answers, with M1 students

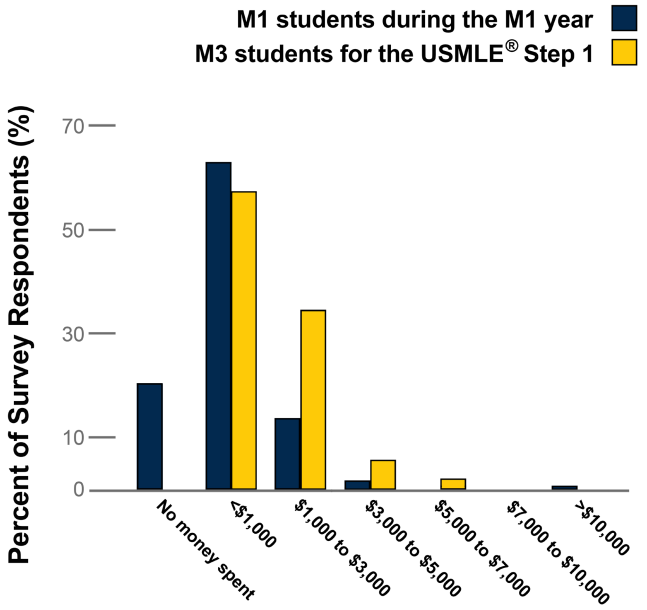

FIGURE 1 Depicted are students' survey responses to the question how much money they spent on additional learning resources including books, e-learning resources, and professional tutoring services (excluding tuition and general items like computers, computer tablets, or smartphone) during the M1 year (M1 class) or to prepare for the USMLE® Step 1 (M3 class)

crediting mainly classmates and M3 students crediting more upper-level medical students. The number of students reporting a UMMS faculty or staff person as the primary recommender for their favorite e-learning resource also differed significantly between the M1 and M3 classes, with their influence being mainly restricted to M1 students.

3.6 | Solitary or interactive study modalities

One set of survey questions asked both classes about the frequency of two study modalities, either studying alone/solitarily or as part of a group (Figure 2). When asked about their study modus for general medical school learning, both M1 and M3 respondents indicated that they "frequently or always" studied alone and "rarely or never" studied as part of a study group. Statistically, the answer patterns for both classes were not significantly different for general medical school learning. However, when M3 students were asked the same questions about their studies during USMLE Step 1 preparation, a highly significant shift to an almost exclusively solitary mode of learning was observed (Figure 2).

3.7 | Students' views on the role of e-learning resources in the learning process

Survey participants were also asked about their opinion for which phases of the learning process e-learning resources are useful (Table 4). Learning and memorization of facts as well as reviewing learning material were named by over 50% of responding students in both classes. The only statistically significant difference between the two classes was an increased use of e-learning tools for examination preparation by M3 students. Very few students viewed e-learning resources as useful for acquiring or improving skills (Table 4).

4 | DISCUSSION

4.1 | Students' preferred hardware devices and general software resources

Despite the overall popularity of electronic devices for medical school learning, a small number of students still preferred traditional learning tools, such as pencils and paper, and physical textbooks (Table 1), something other authors have also commented on.[20,26] Also, smartphones, mobile apps, and social media, although ubiquitously used, were only named by very few students as their most used hardware/software selection for learning (Table 1). Instead, desktop/laptop computers and tablets, which have larger screens and a wider range of software choices, were favored (Table 1). The increased use of computer tablets by M1 students may reflect a general trend of these devices becoming popular primary learning tools.[27,28]

Among the general software options, there was a noticeable popularity of videos with both surveyed classes. This may not be surprising given the current generation of medical school learners grew up with omnipresent TV coverage and experienced internet access since childhood.[15] Medical instructional material in video format is readily available from free sources (e.g., YouTube),[10] as well as from commercial sites (Boards and Beyond, Pathoma, SketchyMedical, and others). Indeed, these commercial resources were among the most popular with both classes (Table 2). However, the published literature argues that many medical instructional videos, especially those that are available for free, often lack the quality to be useful educational tools at the professional level.[29–31] As the use of videos for medical education will likely continue to grow, it will be important to carefully monitor their quality, how they are integrated into curricula, and how they are used by students.

TABLE 3 How M1 and M3 students found their favorite e-learning resource for M1 studies and for USMLE Step 1 preparation, respectively

	Who initially recommended your favorite supplemental e-learning resource to you/persuaded you to use that resource (during the M1 year)?	Who initially recommended your most helpful/favorite USMLE® Step 1 preparation e-learning resource to you/persuaded you to use that resource?	Statistical analysis (chi-square or [a]Fisher's exact test)
	M1 class % ($N = 108$)	M3 class % ($N = 119$)	M1 vs. M3 p-value (odds ratio to be associated with USMLE Step 1 preparation)
Nobody, I did NOT use e-learning resources	1.9 (2)	0.0 (0)	[a]0.23 (0)
I found the resource myself	13.9 (15)	5.0 (6)	0.022 (0.33)
A UMMS faculty or staff person	13.0 (14)	1.7 (2)	0.0011* (0.33)
Blog or online forum	8.3 (9)	14.3 (17)	0.16 (1.93)
(An)other medical professional(s) (not from the UMMS)	0.9 (1)	0.8 (1)	[a]1 (0.91)
One or more of my classmate(s)	47.2 (51)	22.7 (27)	0.0001* (0.33)
Upper-level medical student(s)	14.8 (16)	55.5 (60)	<0.0001* (5.85)
Sum of classmates and upper-level medical students	62.0 (67)	78.2 (87)	0.07 (1.66)

[a]Fisher's exact test.

*Bonferroni adjusted p-value of significance <0.0071.

When comparing e-learning materials used by M1 students against the tools M3 students utilized for USMLE Step 1 preparation, it is evident that many of the materials used during preclinical learning are not considered useful by upper-level students in preparation for standardized examinations (Table 2). This observation has been reported by Burk-Rafel et al. and was confirmed by our study.[11] It indicates that medical students' resource choices are task-oriented, with M3 students often turning to resources specifically designed for the USMLE challenge.

4.2 | The costs of e-learning

Not all medical schools provide personal computers/tablets to their students, and if they do, their use is sometimes restricted to specific courses. This may result in some students not owning the latest hardware devices for efficiently running some educational software tools. As a result, the wide range of different electronic devices used by medical students potentially creates an inequitable learning environment.[32] Students in this study spent significantly more money when preparing for the USMLE Step 1 than for general medical education (Figure 1). Again, many schools may not provide these for profit resources to their students for free. During our study, only Osmosis was available for free to both classes. Locally developed free learning material may decrease the need for purchasing commercial study aids for general medical school learning. However, the perceived need of using such tools for USMLE Step 1 preparation might disproportionally disadvantage students with limited financial resources and pressure schools to provide such resources for free.[32,33]

4.3 | Finding the best e-learning resource for the educational challenge ahead

Considering the abundance of learning resources, choosing the most appropriate learning tools is a difficult challenge. The importance of peer advice for e-learning tool selection has been suggested by other authors.[24,34] The data

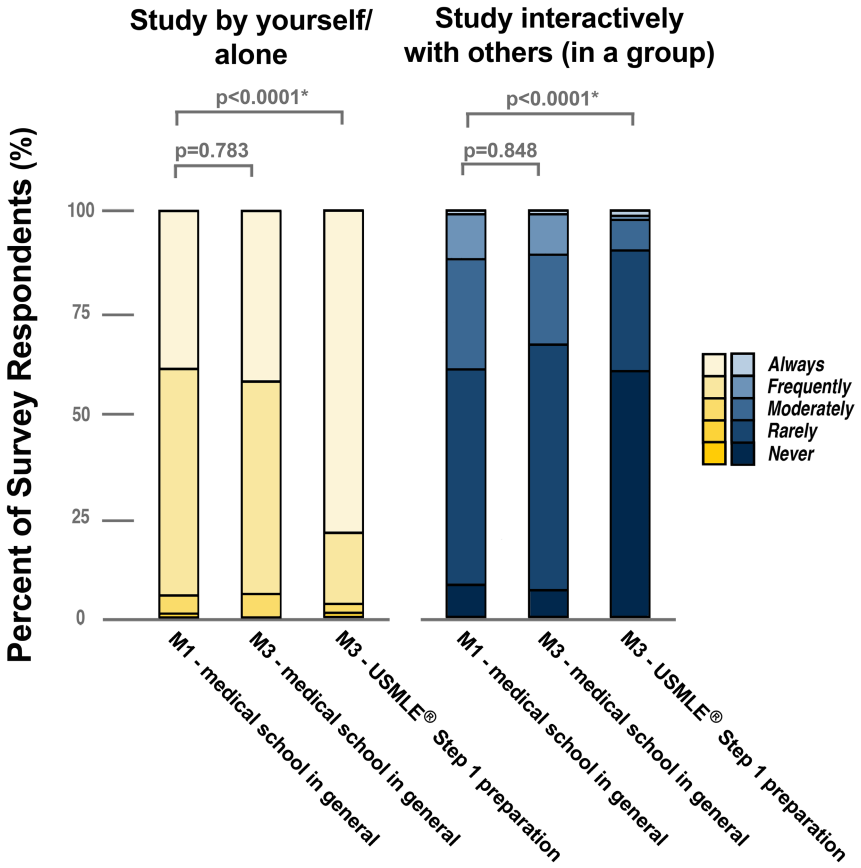

FIGURE 2 Displayed is the reported study modus, either solitary or interactively in a study group, for medical school learning for general medical school learning (M1 and M3) and for USMLE® Step 1 preparation (M3 only). The figure depicts students' answers to the question "How frequently did you use the following study habits." Students' answers about studying alone are represented by the first set of three yellow columns and students' answers about studying interactively with others by the second set of three blue columns. Students' answers reflect their choice from a five-point Likert scale ranging from "Always" (score of 5) to "Never" (score of 1). *p*-values were derived from the pairwise comparison using Fisher's exact test and *p*-values smaller than 0.05 were considered significant and are marked by an asterisks (*)

in Table 3 support one of our original working hypotheses that peer advice is a major driving force for the selection of e-learning tools. Students from both classes mostly credited classmates and upper-class medical students for the selection of their favorite e-learning resource. However, there are additional factors that play a role in the selection of e-learning tools, such as familiarity with the modality and the convenience for students to obtain and use the resource.[35]

4.4 | How medical students view and use e-learning tools

The type of learning resource used by students may also be linked to the learning strategies they adopt.[36] Therefore, we included questions about the general learning modus and how survey participants viewed the usefulness of e-learning resources to support specific steps of the learning process. Many professional school students choose a solitary style of learning.[37–39] In other fields, this behavior of studying alone has been referred to as "lone wolf learner".[40,41] Although this mode of learning is already prevalent for general medical school learning, Figure 2 indicates that the "lone wolf learner" approach is even more dominant when preparing for the USMLE Step 1. This invites the speculation that the observed increase of a solitary learning style may be connected to the use of e-learning resources, which are usually not geared towards team-based learning. However, a more detailed analysis will be necessary to test the validity of this hypothesis.

Students' views for which steps of the learning process e-learning resources are useful also indicate a task-driven approach, primarily for examination preparation (Table 4). Both classes regarded e-learning tools particularly useful for "learning the information or memorizing the facts" and "reviewing the learning material". The only statistically significant difference between

TABLE 4 M1 and M3 students' opinions for which learning steps or strategies e-learning resources are most useful

For which aspects or phases of the medical school learning process are supplemental e-learning resources useful? (Select up to three answers)	M1 class % ($N = 108$)	M3 class % ($N = 119$)	Statistical analysis (chi-square test) p-value (odds ratio to be associated with the M3 class)
For learning the information or memorizing the facts	64.8 (70)	63.9 (76)	0.88 (0.96)
For reviewing the learning material	57.4 (62)	56.3 (67)	0.89 (0.96)
For preparing for an examination	43.5 (47)	76.5 (91)	<0.0001* (4.22)
For supplementing other traditional learning resources	50.0 (54)	34.5 (41)	0.018 (0.53)
For the initial preparation/overview of the material to be learned	27.8 (30)	25.2 (30)	0.66 (0.88)
For substituting for other learning resources (i.e., lectures, books, and others)	18.5 (20)	19.3 (23)	0.88 (1.05)
For refreshing knowledge and skills independently of examinations	13.0 (14)	11.8 (14)	0.78 (0.90)
For improving skills	8.3 (9)	5.9 (7)	0.47 (0.69)
For learning skills	5.6 (6)	4.2 (5)	0.64 (0.75)

*Bonferroni adjusted p-value of significance <0.0056.

the two classes was an increase among M3 students to value e-learning resources "for the preparation for an examination". This may reflect their recent experience of using these tools for their USMLE Step 1 preparation. Surprisingly few students saw e-learning resources as tools for "learning or improving skills" and continuous learning. This suggests that current e-learning resources mainly support fact memorization and answering of examination questions and are not designed for skill building or that students place too much emphasis on fact knowledge and the passing of examinations as the means toward a medical degree.

The data presented in Table 2 also support our second working hypothesis that medical students often use different resources in different phases of their education and that these resources usually correspond to the tasks they are facing at that moment. Whereas lecture handouts and recordings were highly popular during the M1 year, they were rarely reused when M3 students prepared for the USMLE Step 1 examination. Thus, when offering e-learning resources to their learners, educators should be cognizant that these tools are appropriate for the educational challenges their students are presently encountering.

The results of this study indicate that a more detailed analysis about how students are using e-learning resources is needed. The selection of task-oriented learning tools does not necessarily result in their appropriate and educationally most desirable use by all learners and the resources provided by educators might not match with the curricular demands that students are facing.

4.5 | Limitations of the study

The results in this study were retrospective and self-reported, raising the possibility of recall bias. With electronic technologies constantly evolving, the data presented in this article might only provide a current snapshot and students' preferences might change as new hardware and software options become available. In addition, each medical school has its specific and unique learning environment and care should be applied when transferring our findings to other institutions. We cannot exclude that the shift to online training due to COVID-19 pandemic in March of 2020 had an influence on the answers given by the surveyed students. However, we believe that such potential influence did not significantly change their responses. Only the last 2.5 months of first-year medical education were affected for the surveyed M1 class and students' answers were very similar to answers given retrospectively by the M3 class about their previous M1 experience. Also, prior to the pandemic, the majority of UMMS M1 students already worked predominantly online, minimizing their in-classroom time unless personal attendance was mandatory.[42] Equally, most M3 students already had completed their USMLE Step 1 examination when in-class activities were suspended.

4.6 | Conclusions and implications

The use and choice of e-learning resources by medical students is influenced by a variety of different factors,

starting with the curriculum, and the resources offered by the institution. The results of this study suggest some additional consistent themes. Students' choices appear very task-oriented, and they will choose different e-learning resources during different phases of their education according to what they consider most helpful for the upcoming challenge. Many medical students believe that e-learning tools help them to review and memorize information and are less useful for skill building. E-learning tools also cater to the "lone wolf" modus that many medical students adopt for learning, specifically when preparing for professional examinations. As costs of e-learning resources rise, inequities in the learning environment might be exacerbated. In summary, our findings indicate that current e-learning tools are used in rather specific ways and more effort by educators might be needed to enhance their wider appeal and appropriate use by medical students.

ACKNOWLEDGMENTS

The authors thank the members of the UMMS classes of 2021 and 2023 for participating in the surveys that provided the data for this analysis. The authors also thank Ms. Sandy Davis in the UMMS Admission Office for providing some of the demographic data. The authors are grateful to Dr. James Woolliscroft for his helpful remarks on our manuscript draft.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Fred Ayres, Stephen Goldberg, and Michael Hortsch: Conceptualization. Fred Ayres, Stephen Goldberg, and Michael Hortsch: Data curation. Erin Finn and Michael Hortsch: Data analysis. Erin Finn and Michael Hortsch: Original draft. Erin Finn, Fred Ayres, Stephen Goldberg, and Michael Hortsch: Manuscript review and editing.

ETHICAL APPROVAL

This study was approved as exempt/not regulated by the University of Michigan Health Sciences Institutional Review Board (HUM00176873).

REFERENCES

1. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of E-learning in medical education. *Acad Med*. 2006;81:207-212.
2. Ellaway R, Masters K. AMEE Guide 32: e-Learning in medical education Part 1: learning, teaching and assessment. *Med Teach*. 2008;30:455-473.
3. Masters K, Ellaway R. e-Learning in medical education Guide 32 Part 2: technology, management and design. *Med Teach*. 2008;30:474-489.
4. Kumar Basak S, Wotto M, Belanger P. E-learning, M-learning and D-learning: conceptual definition and comparative analysis. *E-Learn Digital Media*. 2018;15:191-216.
5. Hortsch M. "How we learn may not always be good for us" - do new electronic teaching approaches always result in better learning outcomes? *Med Teach*. 2015;37:507-509.
6. Ellaway R. E-learning: is the revolution over? *Med Teach*. 2011;33:297-302.
7. Cook DA, Triola MM. What is the role of e-learning? Looking past the hype. *Med Educ*. 2014;48:930-937.
8. O'Hanlon R, Laynor G. Responding to a new generation of proprietary study resources in medical education. *J Med Libr Assoc*. 2019;107:251-257.
9. Banos JH, Pepin ME, Van Wagoner N. Class-wide access to a commercial step 1 question bank during preclinical organ-based modules: a pilot project. *Acad Med*. 2018;93:486-490.
10. Tackett S, Slinn K, Marshall T, Gaglani S, Waldman V, Desai R. Medical education videos for the world: an analysis of viewing patterns for a YouTube channel. *Acad Med*. 2018;93:1150-1156.
11. Burk-Rafel J, Santen SA, Purkiss J. Study behaviors and USMLE Step 1 performance: implications of a student self-directed parallel curriculum. *Acad Med*. 2017;92:S67-S74.
12. Thadani RA, Swanson DB, Galbraith RM. A preliminary analysis of different approaches to preparing for the USMLE Step 1. *Acad Med*. 2000;75:S40-S42.
13. Zhang C, Rauchwarger A, Toth C, O'Connell M. Student USMLE Step 1 preparation and performance. *Adv Health Sci Educ Theory Pract*. 2004;9:291-297.
14. Parry S, Pachunka J, Beck Dallaghan GL. Factors predictive of performance on USMLE Step 1: do commercial study aids improve scores? *Med Sci Educ*. 2019;29:667-672.
15. Proserpio L, Gioia DA. Teaching the virtual generation. *Acad Manage Learn Educ*. 2007;6:69-80.
16. Talmon GA. Generation Z: what's next? *Med Sci Edu*. 2019;29:S9-S11.
17. Mangold K. Educating a new generation: teaching baby boomer faculty about millennial students. *Nurs Educ*. 2007;32:21-23.
18. Link TM, Marz R. Computer literacy and attitudes towards e-learning among first year medical students. *BMC Med Educ*. 2006;6:34.
19. Kim KJ, Kang Y, Kim G. The gap between medical faculty's perceptions and use of e-learning resources. *Med Educ Online*. 2017;22:1338504.
20. Wynter L, Burgess A, Kalman E, Heron JE, Bleasel J. Medical students: what educational resources are they using? *BMC Med Educ*. 2019;19:36.
21. Khogali SE, Davies DA, Donnan PT, et al. Integration of e-learning resources into a medical school curriculum. *Med Teach*. 2011;33:311-318.
22. MacLean JE, Scott KM, Marshall T, Asperen PV. Evaluation of an e-learning teaching resource: what is the medical student perspective? *Focus Health Prof Educ*. 2011;13:53-63.
23. Rashid A, Prosser-Snelling E, Southern L, Molloy A. The endless potential of social media in medical education. *Med Educ*. 2015;49:947.
24. Cristea AI, Ghali F. Towards adaptation in e-learning 2.0. *New Rev Hypermedia Multimed*. 2011;17:199-238.
25. Daniel M, Monrad SU, Weir S, Kolars JC, Mangrulkar RS. University of Michigan Medical School. *Acad Med*. 2020;95:S249-S253.

26. Holaday L, Selvig D, Purkiss J, Hortsch M. Preference of interactive electronic versus traditional learning resources by University of Michigan medical students during the first year histology component. *Med Sci Educ*. 2013;23:607-619.
27. Purcell K, Buchanan J, Friedrich L. How Teachers Are Using Technology at Home and in Their Classrooms; Part III: Bringing Technology into the Classroom. Pew Research Center; 2013. Accessed December 24, 2021. https://www.pewresearch.org/internet/2013/02/28/part-iii-bringing-technology-into-the-classroom/
28. Zickuhr K, Rainie L. E-Reading Rises as Device Ownership Jumps; Tablet and E-reader Ownership. Pew Research Center; 2014. Accessed January 4, 2022. https://www.pewresearch.org/internet/2014/01/16/tablet-and-e-reader-ownership/
29. Jaffar AA. YouTube: an emerging tool in anatomy education. *Anat Sci Educ*. 2012;5:158-164.
30. Karic B, Moino V, Nolin A, Andrews A, Brisson P. Evaluation of surgical educational videos available for third year medical students. *Med Educ Online*. 2020;25:1714197.
31. Van den Eynde J, Crauwels A, Demaerel PG, et al. YouTube videos as a source of information about immunology for medical students: cross-sectional study. *JMIR Med Educ*. 2019;5:e12605.
32. Vafa S, Chico DE. A needs assessment for mobile technology use in medical education. *Int J Med Educ*. 2013;4:230-235.
33. Beck Dallaghan GL, Byerley JS, Howard N, Bennett WC, Gilliland KO. Medical school resourcing of USMLE Step 1 preparation: questioning the validity of step 1. *Med Sci Educ*. 2019;29:1141-1145.
34. Rashid H, Lebeau R, Saks N, et al. Exploring the role of peer advice in self-regulated learning: metacognitive, social, and environmental factors. *Teach Learn Med*. 2016;28:353-357.
35. Bringman-Rodenbarger L, Hortsch M. How students choose E-learning resources: the importance of ease, familiarity, and convenience. *FASEB BioAdv*. 2020;2:286-295.
36. Mohr AT, Holtbrügge D, Berg N. Learning style preferences and the perceived usefulness of e-learning. *Teach High Educ*. 2012;17:309-322.
37. Holland J, Clarke E, Glynn M. Out of sight, out of mind: do repeating students overlook online course components? *Anat Sci Educ*. 2016;9:555-564.
38. Johnson S, Purkiss J, Holaday L, Selvig D, Hortsch M. Learning histology - dental and medical students' study strategies. *Eur J Dent Educ*. 2015;19:65-73.
39. White C, Bradley E, Martindale J, et al. Why are medical students 'checking out' of active learning in a new curriculum? *Med Educ*. 2014;48:315-324.
40. Kayser I, Merz T. Lone wolves in distance learning? An empirical analysis of the tendency to communicate within student groups. *Int J Mob Blended Learn*. 2020;12:82-94.
41. Barr TF, Dixon AL, Gassenheimer JB. Exploring the "Lone Wolf" phenomenon in student teams. *J Market Educ*. 2005;27:81-90.
42. Zureick AH, Burk-Rafel J, Purkiss JA, Hortsch M. The interrupted learner: how distractions during live and video lectures influence learning outcomes. *Anat Sci Educ*. 2018;11:366-376.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Finn E, Ayres F, Goldberg S, Hortsch M. Brave new E-world: Medical students' preferences for and usage of electronic learning resources during two different phases of their education. *FASEB BioAdvances*. 2022;4:298–308. doi:10.1096/fba.2021-00124