Original Contribution Kitasato Med J 2024; 54: 32–41

Medical students and e-learning: from print- to digital media

Robert E. Brandt,[1,2] Akihiro Takeuchi,[2] Yusuke Hara,[3] Hiroki Chiba[4]

[1] MedEd Japan, Tokyo
[2] Department of Medical Informatics, Kitasato University School of Medicine
[3] Department of Gastroenterology, Kitasato University Graduate School of Medical Sciences
[4] Department of Medical Education, Kitasato University School of Medicine

Background: Information technology (IT) is here to stay. E-learning has replaced textbook-learning and may soon replace in-person lectures by medical teachers. Today's medical students need IT tools and computer skills more than ever. The pandemic caused a worldwide educational disturbance but also led to various new developments in online video education and e-learning. Students' smartphones accessing online dictionaries and medical information became their bread-and-butter batten and sometimes bane of study.
Objective: We sought to emphasize the immediate need for, and to show how to maximize, e-learning so that medical students graduating as doctors will be able to provide their patients with the best medical care possible.
Methods: English level checks using semi-structured interviews for Japanese medical students who applied for international clinical clerkships from 2004 through 2023 were assessed.
Conclusions: Some students improved, while others tested at lower levels than those during pre-COVID years. Some did not recognize related terms in anatomy, diseases, and treatments as they had been taught in Western, evidence-based medicine. Medical students must access valid information on their digital devices to learn correct medical English so that, as doctors, they can provide optimal medical care to their patients. The future of medical education lies in e-learning and teaching students how to use digital media effectively.

Keywords: digital media, e-learning, online dictionary, smartphone, clinical clerkship

Introduction

Medical English education methodologies continue to evolve in all of the 86 medical schools in Japan. Students do their best to keep up with the augmented medical knowledge and evolution of teaching methodologies. As a personal challenge, some further their study of medicine by participating in international clinical clerkships (ICCs) offered in the U.S., Canada, the U.K., Germany, Italy, Singapore, and elsewhere. Others study in basic science laboratories in universities abroad or in short-term programs shadowing physicians to continue their training.

Relatively few Japanese students have lived abroad and studied in foreign countries. Having had scant opportunities to learn spoken English, online English education presents a broad array of possibilities to help Japanese medical students develop their English skills and build their medical vocabulary. It all comes down to how well they can employ information technology (IT) tools to dig into this gold mine.

Medicine and medical education, trying to keep up with it, are evolving at lightning speeds. English is the universal language in this evolution. IT will be needed for healthcare professionals, along with IT skills.[1] Medical students need to acquire these skills throughout their undergraduate and graduate years and for their work as physicians and researchers.

As an interviewer and instructor of conversational and medical English for thousands of students, the lead author (REB) has been involved in ICCs for Japanese medical students for more than 40 years. He has taught

Received 13 July 2023, accepted 2 November 2023
Correspondence to: Robert E. Brandt, MedEd Japan, 3–2–12 Eifuku, Suginami, Tokyo 168–0064, Japan
Email: robertebrandt@gmail.com

students and edited medical papers for physicians in the University of Tokyo, Keio University, Tokyo Women's Medical University, Juntendo University, St. Marianna University, Kitasato University, Tokai University, and many others throughout Japan, online from Fukuoka University in Kyushu to Sapporo University in Hokkaido. Last year, after the major impact of the COVID-19 pandemic, he realized that generally students had improved their English communication skills while their medical vocabulary levels had significantly declined. A language forensic pathology to determine learning aversions or disabilities or to discover patterns of knowledge acquisition, while warranted, was not employed in this study. The hypothesis is that this vocabulary deficiency was an effect of stay-at-home remote learning and augmented by the adjuvant back-to-school flipped classrooms, and whiteboard video dependency, coupled with the students' incompetency using IT tools on their smartphones and tablets for e-learning – the "COVID implosion" on medical education – caused by "the COVI Dragon."

Objectives

The objective results of Japanese students' English level checks led to the empirical hypothesis and search for possible causes for the resultant wide variations, discrepancies, and apparent decline in knowledge of English medical terms and their related anatomy, physiology, pathologies, and treatments. We, therefore, present solutions for improving e-learning methodologies.

Methods

English level check examinations were conducted for students by means of a semi-structured, 25-minute English interview and by evaluating their written English ability via a Personal Statement (PS) essay and a Curriculum Vitae (CV). These and the following items were evaluated on a 1–15 scale. The items included listening comprehension, short-term retention, intonation, fluency, pronunciation, communicative ability, gestures and body language, general and medical vocabulary, meanings and relationships, anatomical locations, pathologies, surgical interventions, therapies, English to Japanese and/or Japanese to English (E–J/J–E) translations, word usage, grammar, syntax, and punctuation (Tables 1 and 2). Common English words and medical terms (Table 1) and medical keyword headings and terms (Table 2), along with standard abbreviations used on patients' medical records, were also tested randomly (Table 3).

The 15 levels were: Beginning, Remedial, Elementary, Basic (Low [L], Middle [M], High [H]); Intermediate (L, M, H); Advanced (L, M, H); and Professional (L, M, H). Rather than merely indications of general communicative English proficiency, these levels are indications of vocabulary knowledge. The relevant levels for an ICC are 9–15: Intermediate High, nearly equivalent to a low-to-average U.S. high

Table 1. Words and medical terms stratified by frequency of usage[a]

Levels						
9-IH	10-AL	11-AM	12-AH	13-PL	14-PM	15-PH
right	stuff	cure	symptom	abstract	obstetrician	obstruct
does	cause	dose	diagnosis	remedy	malpractice	disorder
think	science	chronic	systematic	menstruation	survival	purulent
shot	sign	pregnant	gender	hernia	verdict	discharge
past	medical	risk	rehabilitation	prescription	medicinal	drainage
sure	cycle	vein	infection	intravenous	evidence	ectopic
care	injury	result	therapy	virus	clinician	neoplasm
period	staff	disease	region	tumor	lesion	hematoma
hurt	term	religion	abortion	admission	endoscopy	endothelium
nurses	acute	procedure	recovery	prognosis	systemic	dysfunctional

I, Intermediate; A, Advanced; P, Professional; L, Low; M, Middle; H, High; ICC, International Clinical Clerkship

[a]Based on usage frequency: The American Heritage Dictionary of the English Language, Fifth Edition, 2018; New York, Collins Reference.

Note: Each column represents approximately a 400-word range of that frequency of usage. Levels 1–8 are not relevant for an ICC.

Table 2. Keyword headings and medical terms[a] listed randomly

neurology	anatomy & physiology	orthopedics	dermatology	radiology
cardiology	obstetrics & gynecology	hysterectomy	ophthalmology	immunology
hematology	neonatology & pediatrics	nephrology	otolaryngology	parasitology
hepatology	pathology & oncology	urology	endocrinology	pharmacology
gastroenterology	anesthesiology & surgery	respirology	rheumatology	phlebology
therapeutics	forensics & autopsy	serology	gerontology	psychology

[a]Related terms (truncated, i.e., not shown here) are listed under each keyword heading on the actual examination sheet (e.g., under "cardiology" are: arrythmia, bradycardia, tachycardia, fibrillation, asystole; under "nephrology" are: adrenal gland, diabetes mellitus, insulin, proteinuria, dialysis; and under "phlebology" are: spider, varicose, veins, DVT, etc.).

Table 3. Medical abbreviations[a] listed randomly (*Medalphabet soup*)[b]

Ca, CT (CAT)	CKD	PICU	OBGYN	CPTSD
I/O & F/U	CRC	fMRI	RT-PCR	D & C
MS	ATL	SCT	SARS-CoV-2	DOB/TOB
US	EBM	GVHD	COVID-19[c]	D/TOD
IV & IM	OTC	eGFR	PET/CT	MD & DDS
PD	PPI	GERD	Sx, Hx, DDx, Dx, Fx, Tx, Rx	
DM	HIV	ETT	NSAIDs	x-rays
T2DM	OCD	QOL	His	HER2
U/A	ICU	COPD	Radio	Chemo

Ca, cancer; CT, computed tomography; CAT, computed tomography scan
I/O, in/out balance of fluid intake and volume of urine out put
F/U, follow-up
MS, multiple sclerosis
US, ultrasonography
IV, intravenous & IM, intramuscular (injections)
PD, Parkinson's disease
DM, diabetes mellitus
T2DM, type 2 diabetes mellitus
U/A, urinalysis
CKD, chronic kidney disease
CRC, colorectal cancer
ATL, adult T-cell leukemia
EBM, evidence-based medicine
OTC, over-the-counter (drugs, i.e., pharmaceuticals not requiring a prescription)
PPI, proton pump inhibitor
HIV, human immunodeficiency virus
OCD, obsessive-compulsive disorder
ICU, intensive care unit
PICU, pediatric intensive care unit
fMRI, functional magnetic resonance imagery
SCT, stem cell transplantation; GVHD, graft-versus-host disease
eGFR, estimated glomerular filtration rate
GERD, gastroesophageal reflux disease
ETT, endotracheal tube; QOL, quality of life
COPD, chronic obstructive pulmonary disease
OBGYN, obstetrics and gynecology
RT-PCR, real-time polymerase chain reaction (e.g., test for COVID)
SARS-CoV-2, severe acute respiratory syndrome coronavirus-2
COVID-19, coronavirus disease-19
PET/CT, positron emission tomography/computed tomography
Sx, signs and symptoms
Hx, history
DDx, differential diagnosis
Dx, diagnosis
Fx, fracture
Tx, treatment
Rx, prescription (drugs)
NSAIDs, nonsteroidal anti-inflammatory drugs
His, histidine
Radio, radiotherapy
CPTSD, complex posttraumatic stress disorder
D&C, dilatation and curettage
DOB/TOB, date of birth/time of birth
D/TOD, date & time of death
MD & DDS, Doctor of Medicine & Doctor of Dental Surgery
x-rays, for radiography: chest, bone Fx (fracture), foreign body
HER2, human epidermal growth factor receptor 2
Chemo, chemotherapy

[a]Common abbrevs Drs use on Pts Hosp e-med recs (i.e., common abbreviations physicians use on patients' hospital electronic medical records).
[b]*Medalphabet soup*: medical slang for common abbreviations physicians use.
[c]The COVI Dragon, medical slang for the disease causing the worldwide pandemic.

Table 4. Medical-term vocabulary scores from student interviews

Levels & Year	2004	2007	2011	2015	2019	COVID 2020–2021	2022	2023
Pro–Adv	••	••	•	••	••	NA	••	•••
Adv	•••••	••••	••••	••••	••••	NA	••••	•••••
Adv–Int	••	•••	•••	••	••	NA	•	•
Int	–	–	–	•	•	NA	••	–
Print media[a]	100	75	65	55	50	25	5	2
Digital media[a]	0	25	35	45	50	75	95	98

Comparison of medical-term vocabulary scores from student interviews by year indicating a gradual disuse of print media for study purposes vis-a-vis the developing integration of e-learning via digital media.
[a]Percentage of the type of media students use for study purposes.
•, 11% of students tested; NA, not applicable; –, No student at or below this level

school student's level; Advanced, to an above-average high school student's level; and Professional, to an average university undergraduate's level, respectively. If known, their TOEFL (Test of English as a Foreign Language) and/or TOEIC (Test of English for International Communication) scores were recorded. TOEFL iBT (Internet-Based Test) scores of 100 or higher (equivalent to 12 or higher in the present study) are desirable for students applying to ICCs. These scores are rough indications of English knowledge, not only communicative proficiency, with the caveat that English is the students' second language, not their mother tongue. For all of them, their cradle language was Japanese.

Study design

The study was a retrospective, observational, first-person opinion based on the examiner's (REB) objective and subjective examination results of 137 5th-year Japanese medical students applying for ICCs from 2004 through 2023.

Results

After the major impact of the pandemic, the results evidenced that students had a different understanding of medical English compared to that of pre-COVID students from 2004 through 2019. Some did not equate terms with the related anatomy and physiology and were confounded as to how they correlated with common signs and symptoms, diseases, and the medical and/or surgical treatments taught in their curricula of allopathic medicine (Western, evidence-based medicine [EBM]). This phenomenon may be an occult learning deficiency, not proven or readily indicated. This decline in comprehension may be a result of teacher-absent, student-self-taught e-learning.

With the exception of the 2-year educational hiatus (2020–2021) due to the pandemic, Table 4 shows a comparison of students' English levels from 2004 to 2023. Over those 19 years, their communicative ability and written PSs and CVs have improved (in part, thanks to international travel, Facebook, Twitter, Instagram, YouTube, Google, Wikipedia, and "copy-paste"). In 2023, an improvement was indicated. However, the resultant medical vocabulary, written grammar, and punctuation levels did not improve equitably.

In 25-minute interviews, it is challenging (if not impossible) to check everything and ask all the questions the examiner would like. Thus, hidden issues or language problems might have gone underreported. The following interviews from either 2022 or 2023 (including incidental J–E/E–J translations) demonstrate wide variations in abilities.

Student 1

(Examiner points to terms in Table 2.) *"Would you read these aloud?"*

St: *"Nephrology, adrenal gland, psychology, dialysis."*

Ex: *"Do you know these terms?"*

St: *"Yes."*

Ex: *"What organ in the body is related to three of those terms, and what term isn't related so closely to the others?"*

St: *"Kidney is the related organ. Psychology is not related."*

Ex: *"How do you say 'touseki' in English?"*

St: *"Dialysis."*

Ex: *"What's it a therapy for?"*

St: *"Proteinuria, CKD, or diabetes."*

Ex: *"What does CKD stand for?"* (Testing to see if the student knew the full term.)

St: *"Chronic kidney disease."*

[Comments: Good attitude, well-motivated; ICC – OK]

Student 2

(Examiner points to "endocrinology" in Table 2.)

Ex: *"Do you know this term?"*

St: *"Naibunpigaku."*

Ex: *"Would you explain it?"*

St: (Silence)

Ex: *"Endocrinology relates to what other of these terms?"* (Pointing to terms while reading them out loud): *"Heart, brain, adrenal gland, mammary gland, prostate gland, nephrology, dialysis."*

St: *"Glands, nephrology, and dialysis. Not heart and brain."*

[Comments: ICC – Perhaps, with significant improvement]

Student 3

(Under "surgery," the examiner points to "appendectomy" in Table 2.)

Ex. *"Do you know this term?"*

St: (Silence)

Ex: *"It's a surgical procedure. Would you explain it?"*

St: (Silence)

Ex: *"An appendectomy is a surgical resection. What part of the body is removed?"*

St: (Silence)

Ex: (Pointing to the term above it, "appendix") *"Do you know this term? . . . In Japanese?"*

St: (Silence)

Ex: *"'Chuusui' Right?"*

St: (Nods)

Ex: *"Would you point to where it is in the body? – Right or left side?"*

St: *"Left?"* (Pointing to the spleen)

[Comments: ICC – Not recommended]

Interpretation of students' proficiencies

The 2022 and 2023 students' written work was passable if one overlooked common grammatical errors in spelling, punctuation, syntax, verb tense, plurals, and noun/pronoun agreement. The results evidenced that their communicative ability was more fluent and natural compared to pre-COVID pandemic students' who had studied from printed textbooks and dictionaries – pre-online e-learning. However, the vocabulary results, especially the medical vocabulary of students during and post-COVID pandemic, were further down the curve. While their comprehension of a solitary term, its meaning, and Japanese translation might have passed the initial bar, their grasp of that particular term's relation to other terms, anatomy and physiology, signs and symptoms, diagnoses, treatments, and possible pharmacologic, rehabilitative, or therapeutic remedies was far from comprehensive. These discrepancies evidenced that some candidates did not have the requisite level for an ICC.

This retrospective, observational study was based on the objective and subjective results of English level-check examinations given by one examiner to 137 5th-year Japanese medical students and, therefore, reflected the examiner's first-person perception and opinion. The examiner's concerns about possible future consequences that students may incur while studying abroad might have precluded a bias. Students in this series all expressed their dream to study abroad. They likely assumed that applying for an ICC implied that they were motivated and knew English well enough. The variations in their comprehension of medical terms might have resulted from their history of language acquisition, their individual attitudes toward learning, and their way of studying, reflecting their ability to use IT tools.

A physician's truncated perspective

From his PS for a second clerkship, a former Japanese student who attended an ICC in Germany, previous chief resident (YH) of the Department of Gastroenterology, Kitasato University Hospital, wrote:

> "Nowadays, many foreigners, visiting and living in Japan, consult Japanese physicians. Some foreigners speak Japanese, others don't. So it's important for Japanese physicians to talk with them in English. That's why I applied for the clerkship in Philipps University Marburg, 7 years ago, and last year to the U.S. Naval Hospital Yokosuka clerkship. I'll do my best to be an internationally minded physician and treat all my patients to the best of my ability."

This excerpt and his personal example show how ICCs are meant to work, by helping students and physicians continue their education and training and broadening their outlook and experiences.

Discussion

Giving these 137 interview examinations, the examples that could have been given are exhaustive. But these three demonstrate that the students' command of English varied widely. After the brunt of the pandemic, students said they rarely use print dictionaries or resources (maybe as little as 2% of their study time) but use digital sources on their smartphones and tablets (98% of the time). And without them, they said that they would be lost. Thus, the hypothesis of this article: that student use of online dictionaries and educational resources, depending on how they are employed, may have both beneficial and detrimental effects on their grasp of medical concepts and vocabulary (Table 4).

Japanese medical students better buckle down and learn how to use IT tools for English apps. We medical teachers have to help them understand and work with "medalphabet soup" because of its necessity in medical education and acquiring information and because it is mostly based on English (Table 3).

To improve students' literacy in medical English and globally recognized anagrams, medical teachers in Japan conduct self-inspection work in efforts to reach the WFME (World Federation for Medical Education) standard. Thus, improvements in e-learning and teaching methodologies using ICT (information and communication technology) are continually being made. We must teach undergraduates how to use IT tools correctly, for their pre-grad studies and post-grad work, when they become practicing physicians or biomedical researchers, so that they can continue their medical education.

In Canada's McGill University, teachers use IT tools and YouTube whiteboard videos to teach deprescribing guidelines.[2] Students found e-learning relevant and practical giving them ideas how to provide effective patient care.

Educators at Johns Hopkins University reported that they must formulate new methodologies to develop IT educational media.[3] To learn new medical technologies, students will have to keep up with new digital English apps. These have had an effect on students' deep structure learning, efficiency, and engagement.[3] Digital technology and IT-based learning are necessary for student-participatory interactive medical cases, using artificial intelligence (AI), virtual reality (VR), and augmented reality (AR) to prepare new and intriguing illustrative diagrams, PowerPoint presentations, and video media designed to hold students' interest, allowing them to visualize what it is they are studying. How physicians use AI to work through their differential diagnoses and to prepare patient treatment plans in the hospital or clinic may most likely be totally unlike how med students use AI in their collaborative studies in IPE (interprofessional education).

Many undergraduates have never thought about, or could even imagine, what actually exists in the real world of the deeper intricacies in medicine. Imaging technologies, radiology, computed tomography (CT), magnetic resonance imagery (MRI), functional magnetic resonance imagery (fMRI), multiple color Doppler 3D-US (3-dimensional ultrasound), and videos are all part of and augment e-learning. Teachers should encourage students to use tablets more than smartphones because 3D and animated illustrations in VR, AR, and videos are seen more vividly on tablets than on small-screen cellphones. Online seminars, webinars, workshops, podcasts, and analog or digital devices using AI, VR, and AR will soon be as natural, commonplace necessities, as keyboards are nowadays to navigate medical information the only way possible, in digital formats, in mixed reality to back it all up. Therefore, techniques incorporating AI, VR, AR, and IT innovations have to be developed in medical schools to maintain students' interest and augment their education, evolving naturally into this new world of AI-generated mixed reality.

With students learning via e-learning, some, perhaps those at the lower end of the standard deviation on the bell curve, do not correctly understand certain English and Japanese medical terms and the related anatomy and physiology. The examiner theorized that this problem came about because students see only what they access on their smartphones and tablets. With e-learning, it is totally different than flipping through printed pages of textbooks and dictionaries, digging in, seeing what comes first, what is next, their relation, and even what is irrelevant, but often learned at a glance, coincidentally, as if by osmosis.

The online dictionaries and educational resources, with all their technological intelligence and convenience, provide students with meanings and direct translations, and sometimes confounding lists of terms. Students do not know what they are looking up. That is "why" they are looking it up in the first place – to find out what it is and to learn it. So, from these lists, and multiple screens of information, how are they expected to know, scrolling up and down, what is the correct term or information to focus in on, study, learn, and remember? Moreover, much of that information has not been fact-checked, peer reviewed, or edited.[4] How can they be expected to know what is valid and what is not? Misinformation, mistakes, and typos abound on the Internet. Medical students incur these dilemmas daily in their studies. But still, they learn as best they can. Unfortunately, Japanese students currently do not systematically learn how to use IT to augment and enhance the effectiveness, breadth, and depth of what it is they are learning. We medical teachers have our jobs cut out for us. We have to teach them how to use IT tools to access the right information efficiently. We have to motivate them and teach them to dig in and click more multiple screens, accessing the deeper structures of whatever it is that they are studying.

The COVID pandemic has not only put a halt on the ICCs from 2020 through 2022 but also added unique challenges to the traditional, in-print, in-person approach to medical education. The silver lining was that it provided motivation toward technological innovations for novel EBM-based educational methodologies. It is our job to enhance these new e-learning methodologies by implementing educational approaches, including observation and practice, with views toward more 5th-year students' participation in online English clerkships and ICCs. If students cannot attend an ICC, we must eliminate technical problems with the Internet for "online" English clerkships so that their effectiveness is not substantially reduced.[5]

Theoretically, at least, in medical schools, course completion indicates effectiveness. Empirical evidence reveals that online courses and lectures have higher dropout rates compared to in-person courses.[6] It has been reported that dropout rates indicate reduced effectiveness. Teachers must remedy this with appealing and engaging e-learning techniques.

Pre-COVID anatomy education in the U.S. was different from that during the pandemic. Cadaver use decreased 25%. Laboratory classes used 50% digital resources and 25% dissection and/or prosection, while instructors incorporated more e-learning because of the COVID implosion on medical education.[7] The pandemic forced students into new methodologies of e-learning medical realities, where things can be visualized (CT, MRI, fMRI, and 3D angiography) or seen in reality (second-year anatomy dissection and prosection classes); but then, may be too early; (or in forensic or autopsy examinations); but by then, may be too late.

Considering the discrepancies in knowledge of English anatomy and physiology terms (See Students 1–3 above), merely learning where something is in the human body, what it does, what it secretes or expels, and how it works is not enough to graduate from med school. Students also have to learn the related signs and symptoms when a body part is injured, damaged, diseased, or somehow becomes dysfunctional, but, not only that, more importantly, how to fix it. Flipping from anatomy and physiology in English and Japanese, and back and forth, is challenging enough for students dependent on e-learning. But for them to learn from online sources and practice surgical techniques will likely be exceedingly challenging, if not impossible. While flipped learning has been incorporated into e-learning, flipped classrooms are unsuitable for training surgical techniques. The remarkable flipside of that is, that e-learning has enabled well-motivated students, who had not received hands-on ligation training, to acquire basic ligation skills,[8] proving that e-learning has helped peak and keep their interest.

Even if there are alternate considerations, online education and training are recommended in the beginning stages of learning new skills. E-learning, flipped classrooms, IT innovations, online dictionaries and educational resources, AI, and ChatGPT (Chat Generative Pre-trained Transformer) are here to stay. They have become integral parts of our culture and our English medical education. How Internet-based e-learning affects med students' motivation, behavior, and overall learning to become doctors, is the imperative question. Once they become doctors, with practice, they gradually get better at it. "It is time to move towards determining whether [or not] improved self-efficacy or knowledge gained through e-learning improves patient outcomes."[9]

A treatise on students' receptiveness of the methodology of e-learning, such as this, warrants a candid view from their own perspective. Students and teachers at Gabriele d'Annunzio University of Chieti-Pescara, Italy, shared insights from their experience with e-learning.[10] Students appreciated the methods and efforts instructors made in e-lectures, although they complained that their instructors' lack of technical skills in practical online education presented problems.[10] Some students found e-learning useful, time saving, and liked the flexible study environments. Problematic issues included: Internet and computer problems, unstandardized teaching methods, and lack of quality assurance and experience beyond medical school lectures.[11] Without a more comprehensive program and challenging, allopathic and osteopathic, EBM curricula, lectures, and traditional courses will fail to achieve their purposes.

Over the past 16 years, there have been increases in e-learning, including virtual slides, in teaching histology, and mixing computer-based instructional technologies with microscopes and glass slides.[12] Medical teachers are mixing "e-bench" with wet-bench teaching. In the University of California Irvine, histology education is seen through digital and virtual microscopy,[13] allowing students to visualize histology anywhere, anytime. Medical education has become smartphone-flexible, self-learning through social media, live-streaming, VR, AI, and ChatGPT.

The effectiveness of VR technology for teaching pediatric surgery was studied in Tokyo Medical and Dental University. For diagnostic imaging in cases in which understanding the 3D structure of organs is difficult, students who previously viewed a VR image and then confirmed it with a CT image tested significantly higher in less time,[14] proving VR technology incorporating visualization is efficient and effective.

Medical students are expected to learn through online and in-person lectures, whiteboard and PowerPoint presentations, wet labs, bench labs, and peer study groups, but mostly through dedicated self-learning – burning the midnight oil (and making sure their batteries are charged). E-learning, online dictionaries, and other digital resources have become integral parts of their education. Students no longer open dictionaries and medical textbooks, wade through myriads of medical terms and definitions, and try to figure out the salient points of tables and figures. Instead, they pull out their smartphones or tablets and get an instant term, direct translation, definition, and hopefully a bit of valid instruction. To see what it looks like, and where it is in the human body, they have to click a link to access another screen. Juxtapositionally, it is hard for them to fathom whether what they are looking at is proximally or distally, superiorly or inferiorly apposed to what other organs and/or structures they are studying.

Physicians are responsible for the medical care of patients. They are not professional teachers. In medical schools, doctors are expected to teach students even though they never took teaching courses themselves. Doctors do not learn how to teach but are expected to "share" their knowledge. The reasoning is clear. They did it, so now they can help others do it.

Medical teachers have to teach students navigation and validation techniques and shortcuts using their digital devices in English. If Japanese students first have to look up a term in Japanese and then get the correct English translation, there are too many places where things can go wrong. The first difficulty is finding the correct term.[15] Understanding medical English terms and deciphering "medalphabet soup" are not easy for students using online dictionaries (Tables 2, 3).

The problem is that if accessing a term to get a translation and definition is difficult, students will allocate that for later and move on to another topic. Medical students are industrious yet economical in their study methods and use of time. Therefore, medical teachers need to help them learn how to learn quickly using online dictionaries and digital texts, how to access the cornucopia of digital media readily available to them, and then how to discern what of it is correct and valid information that they need to remember. They should always check to ascertain if the information is from a reputable medical source. By checking author affiliations and journal homepage validations, students can confirm whether or not online sources have been peer-reviewed by native English-speaking professionals. In lieu of that, if they confirm that the target concept is identical in two or three different, unrelated sources, they could consider it valid.

The problems with online material is that much of it has not been fact-checked, peer reviewed, or edited[4] as are articles in print media. This problem is exacerbated because students may google a medical condition and access "fake news." Moreover, much material online is not supported by evidence. "Do right and wrong answers still exist in medicine?"[16] Sure. The issue is confounded by even some physicians spreading misinformation on social media (e.g., the falsehoods about coronavirus-19, its treatment, and prevention).

The problem in medical education is that many students, searching online for answers, cannot discern what is valid or invalid. They study the material they access, thinking that it is correct, and learn what they think is most important. Their reading follows their interest, so their learning tends to be fragmented knowledge. They are under the visualization spell and harbor the impression that if the AR scientific automated image is in color and 3D, and the contents are simply displayed, then their quick response is to take a deeper look and learn it. Too often, it becomes unstructured or unsystematized in their minds. For school tests, this fragmented e-learning may be okay. But, when they become doctors, in real-time clinical settings, talking with patients, taking detailed histories, noting their chief complaints, signs and symptoms, conducting physical examinations, performing the necessary tests, making the differential and determining the working diagnosis, then treating and following up patients, fragmented e-learning will never do.

Students need to read valid, peer-reviewed, and edited medical texts, not just eye-appealing, AI-generated lists of symptoms, diseases, diagnoses, and therapies. Machine-learning methods for analyzing datasets have yielded clinically directive information, mostly for rare genetic diseases.[17] Students need to get it right, to learn how to work with machine-learning methods to learn basic science supported by evidence. If they are not careful, they may be susceptible to the spread of misinformation. Diligence has to be trained when they are students so that, as physicians, they may be sure they are giving patients accurate information.[4] That cannot come from fragmented knowledge. It has to be structured. Medical teachers have to teach students how to access correct information, then, as physicians, they will be able to provide their patients with the best medical care possible.

Taking steps toward solving these problems that result in fragmented knowledge, researchers from King's College London, presented twelve tips to assist students during the pandemic to get the best structured results from their individual home study depending on synchronous and asynchronous remote learning using their smartphones and tablets.[18] Not all the problems have been solved, but these twelve tips help greatly.

Among the educational technologies helping medical students along their paths toward becoming doctors who will provide patients with gold-standard treatments, e-learning, with smartphones and tablets accessing online dictionaries, medical, pharmacological, and other critical information, is branding its impact on the deepest structures of efficient, effective, specialized medicine. IT is here to stay. The future of Japanese/Western medical English education is in IT (the provider of medical knowledge) and in the ubiquitous, handheld devices.

Conclusions

We see the red flags. Japanese medical students' education and Japanese/Western medicine itself are in critical condition. "Code Blue . . ." could be called, like in U.S. hospitals, to ready staffs for emergencies. Because there are no classes in Japanese medical school curricula in e-learning, students have to learn by themselves how to handle their tablets and smartphones to access online dictionaries, wade through myriads of digital materials, multifarious digital resources, and sift out what is misinformation, what is valid, and what is necessary. The armamentarium of teaching methodologies for Japanese medical students who are e-learning medical English terms with new apps is in critical need of being increased. Medical teachers must teach students how to navigate through valid digital material so they can graduate and receive their MDs. They will become doctors who whip out their smartphones to get the necessary information, some of which may be AI-generated that enables them to treat their patients properly and to cut down on hospital length of stay, prescription dosages, morbidity, and mortality. Medical students need IT and e-learning to acquire the technological know-how and medical information to not only pass medical exams but to become doctors of the highest quality and provide their patients with the best medical care possible.

Two key take-home points for medical teachers using digital media

1. Encourage students to use tablets more than smartphones.
2. Teach students how to access correct information and navigate through valid digital material.

Twelve key take-home points for med students using digital media

1. English is invaluable.
2. Misinformation, mistakes, and typos are massive on the Internet.
3. With correct e-learning, you will graduate and get your MD.
4. Medical education is tablet and smartphone flexible.
5. Learn through online and in-person lectures, IPE peer study groups, but mostly through self-learning.
6. Use your tablet or smartphone to get a term, direct translation, definition, and valid instruction.
7. Check that the information is from a true medical source: check author affiliations and journal homepage validations.
8. Confirm what you look up is the same in two or three different sources.
9. Read valid, peer-reviewed, and edited texts, not just AI-generated lists of symptoms, diseases, diagnoses, and therapies.
10. Get it right. Learn how to work with machine-learning methods.
11. Learn by yourself how to handle your tablet and smartphone to access dictionaries, go through

materials and resources, and know what is misinformation, what is valid, and what is necessary.

12. Use IT and e-learning to acquire tech know-how and med information not only to pass your med exams but also to become the best doctor you can be.

Acknowledgments

We are indebted to the 137 5th-year Japanese medical students who applied for ICCs from 2004 through 2023. We thank Takashi Katakura, PhD, Department of Physiology, Kitasato University School of Medicine, for invaluable discussions and helpful advice. We also thank Daniel Brandt, Managing Director, MUFG Securities Americas, San Francisco, CA, USA, for contributing ideas regarding the purpose and utility of the study.

Conflicts of Interest: None

References

1. Masys DR. Advances in information technology. Implications for medical education. *West J Med* 1998; 168: 341–7.
2. Farrell B, Grant RE, Dilliott D, et al. Lessons learned from using whiteboard videos and YouTube for deprescribing guidelines knowledge mobilization. *Int J Pharm Pract* 2022; riac054.
3. Day J, Devers CJ, Wu E, et al. Development of educational media for medical trainees studying MRI physics: effect of media format on learning and engagement. *J Am Coll Radiol* 2022; 19: 711–21.
4. Brady JT, Kelly ME, Stein SL. The trump effect: with no peer review, how do we know what to really believe on social media? *Clin Colon Rectal Surg* 2017; 30: 270–6.
5. Kuroda N, Suzuki A, Ozawa K, et al. Educational approaches that enhance online clinical clerkship during the COVID-19 pandemic. *Intern Med* 2022; 61: 2431–40.
6. Hachey AC, Conway KM, Wladis C, et al. Post-secondary online learning in the U.S.: an integrative review of the literature on undergraduate student characteristics. *J Comput High Educ* 2022; 34: 1–61.
7. Attardi SM, Harmon DJ, Barremkala M, et al. An analysis of anatomy education before and during Covid-19: August-December 2020. *Anat Sci Educ* 2022; 15: 5–26.
8. Okada T, Asao T, Inoue H, et al. Retrospective study of online ligation student practice incorporating flipped learning into e-learning. *Surg Today* 2022; 52: 1–8.
9. Sinclair P, Kable A, Levett-Jones T. The effectiveness of internet-based e-learning on clinician behavior and patient outcomes: a systematic review protocol. *JBI Database Syst Rev Implement Reports* 2015; 13: 52–64.
10. Varvara G, Bernardi S, Bianchi S, et al. Dental education challenges during the COVID-19 pandemic period in Italy: undergraduate student feedback, future perspectives, and the needs of teaching strategies for professional development. *Healthcare (Basel)* 2021; 9: 454.
11. Suzuki T, Murayama A, Kotera Y, et al. Cross-country student perceptions about online medical education during the COVID-19 pandemic. *Int J Environ Res Public Health* 2022; 19: 2840.
12. Bloodgood RA, Ogilvie RW. Trends in histology laboratory teaching in United States medical schools. *Anat Rec B New Anat* 2006; 289: 169–75.
13. Chapman JA, Lee LMJ, Swailes NT. From scope to screen: the evolution of histology education. *Adv Exp Med Biol* 2020; 1260: 75–107.
14. Okamoto K, Ogino K, Ito Y, et al. Effectiveness of virtual reality technology for medical education. *J Jpn Soc Pediatr Radiol* 2021; 37: 68–74.
15. Tateisi Y. Resources for assigning MeSH IDs to Japanese medical terms. *Genomics Inform* 2019; 17: e16.
16. Baron R, Ejnes YD. Physicians spreading misinformation on social media – do right and wrong answers still exist in medicine? *N Engl J Med* 2022; 387: 1–3.
17. Gomes B, Ashley E. Artificial intelligence in Molecular Medicine. *N Engl J Med* 2023; 388: 2456–65.
18. Mittal S, Lau V, Prior K, et al. Twelve tips for medical students on how to maximise remote learning. *Med Tech* 2022; 44: 851–8.