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Medical education in pediatric and congenital heart disease: A focus on generational learning and technology in education

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ABSTRACT

Medical education is a complex interplay between teacher and trainee with the ultimate goal of producing competent physicians who provide excellent patient care. Physician education has evolved over centuries, from the apprenticeship of barber-surgeon through generations of bedside teachers and now evolving use of technology based instruction. All of these educational practices are based on expert assessment of effective techniques for imparting experience and knowledge to a new group of learners, the young doctor. In the past several decades, exponential growth in both medical innovation and technology development has occurred, leaving the current landscape of medical education with a substantial amount of medical data as well as innovative platforms for information access and distribution. These rapid changes have led to stark differences between medical educators and learners in their world views and preferences relating to teaching and learning. Therefore, understanding how the current generation of medical trainees perceives the world, accesses and retains information is imperative to effective education. The concept of generational learning can be used as a framework to identify teaching and learning preferences and help build relevant and effective educational content. This review article aims to outline our current understanding of generational characteristics, learning styles, and preferences. Using this framework, we will explore innovative educational content relevant to pediatric cardiology. Finally, we propose that a methodical approach to curriculum development will forge this generational gap and lead to even more effective and sharable educational content within our field.

1. Introduction

From a historical perspective, we have come far in medical education from the apprenticeship of barber-surgeons to the auditorium classroom setting with limited patient contact to residencies and fellowships with combined didactics, apprenticeship, bedside teaching, and experiential learning. In the current era, educating medical trainees is an interplay between teacher and learner, allowing expertise to be passed from one to the other in a manner that promotes retention. As important as the content is the method by which that content is delivered. Effective education promotes a change in learner behavior and ultimately improves patient care [1]. The key to success for educators in any profession is to understand the learner. While individuals can have different learning preferences and styles [2], generational characteristics provide shared attitudes and core values that are common to a group of medical trainees. Understanding these generational characteristics can help educators choose instructive methods tailored to their audience.

2. Generational learning

The concept of generational segmentation originated in the business world, allowing marketing teams to understand consumer preferences in order to better sell products [3]. Characterizing a generation of peers is not an exact science and relies on the premise that peer groups, born within a 15–20 year time span, have similar attitudes, core values, and views on family and work-life integration. In addition, they share common teaching and learning styles that are shaped by common experiences. The current generation of pediatric cardiology fellows is mostly comprised of individuals born between 1981 and 1995, known as Generation “Y” or the Millennial Generation. This generation's childhood experience was shaped by a time of exceptional wealth in the United States, a more guarded school and society experience with more adult supervision than previous generations, and unique methods of personal interaction [4,5]. During their childhood, the world also saw exponential growth in technology and connectivity, making them technologically fluent and even dependent on technology as a preferred

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method of communication [4]. At the same time, Generation Y grew up in a time of commonplace school violence, September 11th and other threats of terrorism, globalization, and ultimately a severe economic recession [6]. Common characteristics of the Millennial Generation include optimism, the desire for frequent feedback, collaborative learning and engagement, and technical sophistication. As a group, they have been described as entitled and empowered, partially due to their being included in decision-making at an early age and having caretakers who gave them praise without qualification [4,7]. In a work environment, they prefer group interaction and hands-on experience; they enjoy trial and error over reading and sitting in typical classroom style didactic lectures [8,9]. This generation values creativity, close relationships with authority figures, and peer interaction. They are generally innovative thinkers [6].

Generation Z, individuals born between 1996 and 2012, are the rising generation of learners, now entering the medical education system. While they share some overlapping characteristics with Generation Y, they also have some unique attributes. They were quite young or not born for the September 11th bombings but they lived through the after-effects including global terrorism and ongoing wars. They experienced natural disasters and associated looming concerns about climate change, school violence, identity theft, online hacking, and bullying [10]. They are digital natives, being the first generation to have always had social networking and having been raised knowing how to use technology.

Generation Z values diversity, advocates for social justice and have a desire to please. They can be insecure in their in-person interactions because they have interfaced with technology for much of their lives. Along with Generation Y, they value the use of technology, teamwork, on-the-job learning with frequent feedback in the learning environment. They are accustomed to close relationships with authority figures and value work-life integration. Unique learning preferences for Generation Z include the desire for a more “customized” experience with the expectation of on-demand information and 24/7 access to educators. They tend to procrastinate and do not value course work that they view as irrelevant [10–12].. Overall, they are collaborative by nature and thought to be good problem solvers.

3. Generation gap

The majority of medical educators in the current workforce belong to either the Baby Boomer generation (born 1946–1964) or Generation X (born 1965–1980). As with Generation Y and Z, these groups have had unique life experiences that have shaped common characteristics and learning preferences. Baby Boomers' formative years saw the Vietnam War, civil rights movement, and overall prosperity. Boomers are generally described as physically fit, hardworking, independent, and resourceful with a competitive drive. They are also resistant to change and often not technically-savvy. Generation X's upbringing was marked by the advent of the personal computer, cable television, HIV, and women's rights. Generation X has an increased comfort with technology and are described as independent, adaptable, and sometimes impatient.

Differences in life experiences between teacher and learner can forge a generation expectation gap, with each party perceiving that they hold the best or only way to accomplish goals [14]. Navigating this generation gap is most successful if the educator understands their own biases and can appreciate the perspective of the current generation of learners. Experienced physicians have important knowledge and expertise to impart to a new generation of physicians, thus prioritizing effective educational tools that are tailored to today's medical learners is key to making this interaction successful. Summary of generational characteristics and learning preferences is seen in Table 1 [13]. Techniques for effective engagement of Generation Y and Z include framing the importance and relevance of aspects of medical knowledge, keeping teaching fast-paced and relevant, using technology, and integrating

Table 1
Generational characteristics and learning preferences.
Adapted from a table in Hopkins et al. [13].

Generation	Birth years	Current age, y	Defining cultural events	Character traits	Learning preferences
Baby boomers	1946–1964	56-74	Vietnam war, civil rights, prosperity	Self-centered, driven, resourceful	Intimate learning environment, lectures, reflection, expert feedback, reading books
Generation X	1965–1980	40–55	Personal computer, cable TV, HIV, women's rights	Independent, adaptable, inpatient	Structured learning, small groups, self-directed opportunities
Millennials, generation Y	1981–1995	25–39	Wealth, 9/11, mobile devices, terrorism, sexual rights	Optimistic, tech-savvy, hungry for feedback, group oriented	Teamwork, close relationships with authority figures, interactive learning, work-life flexibility, use of technology
Generation Z	1996–2012	8–24	Global conflict, natural disasters, school violence, recession, social networking	Diverse, advocates for social justice, desire to please, problem solvers, insecure	Customized learning experience, hands-on learning with customized feedback, technology heavy, on-demand information, expectation of instructor availability 24/7

hands-on learning [14].

The current generation of trainees would benefit from being open to teaching strategies that have proven effective over decades. For example, accruement of knowledge and expertise in complex decision-making should be observed, valued, and emulated. Role modeling is a fundamental technique in medical education and exemplifies a traditional teaching practice with sustained importance. Furthermore, trainees should be cognizant that the use of technology in some educational settings can have negative implications with the learner being perceived as rude and disengaged by the educator. The generational expectation gap requires an understanding by both parties involved in the teaching/learning unit. Verbalizing clear expectations surrounding the appropriate use of technology can help avoid misunderstandings between teachers and the current generation of trainees.

4. Customizing our learning environment

While we should be careful about stereotyping individual learners, understanding shared experiences and learning preferences can help curriculum development by planning academic infrastructure and personnel required to support contemporary learning [14]. Through faculty development, educators can be equipped with the skills to actively engage a new generation of learners. Many of the learning preferences of Generations Y and Z lend themselves to increased use of technology in medical education. Predilection for interactive learning and dislike of traditional didactic lectures lends itself to online learning with interactive elements. Online learning has the advantage of being asynchronous, providing flexibility to learn on your own schedule, and allowing for efficient use of trainee time and respect of duty hour requirements. Online elements are easily accessible in today's world, easy to update and sharable between institutions, with the added benefit of more efficient use of faculty time. In addition, online technology allows for interactive elements (gaming/simulation), instant feedback, tracking of progress, and assessment of skills; all elements that satisfy the learner and unburden the teacher. While online education will never replace bedside and clinical instruction in medical education, it may be complementary or even substitute for traditional lectures.

5. Online education and COVID

The coronavirus pandemic has suddenly and dramatically changed the landscape of medical education, perhaps permanently. With graduate and post-graduate medical education shifting to more socially distanced platforms, the use of technology has suddenly become essential. Developing and sustaining high-quality methods of virtual education has been thrust to the forefront of educational priorities [15]. Pediatric cardiology lends itself to the use of technology in education. It is relatively easy to share and view images of echocardiograms, cardiac MRI, or angiograms on a virtual platform. Education during COVID has also enabled us to reach learners across the globe.

6. Education technology and pediatric cardiology

Educators in our field have been developing and delivering contemporary resources to meet the needs of our current generation of trainees. Although not comprehensive, this section will outline some of the existing resources in pediatric cardiology education that are widely available to today's trainee.

Online learning modules are one format which allows didactic material to take on interactive features and can be coupled with assessment and feedback. This format allows 24/7 access to users and can provide tracking pre/post testing. Pediatric Echocardiography (Pedecho.org) is an interactive website created by Texas Children's Hospital that provides learning modules for the normal transthoracic and fetal echocardiogram along with atrial and ventricular septal defects [16]. Open Pediatrics is an open access, online community sponsored by Boston Children's hospital which aims to share best practices using digital learning technology. They have interactive content, predominantly related to pediatric intensive care, but includes learning videos on pediatric cardiology topics. In addition, this website hosts a live speaker series on a wide variety of topics relevant to pediatric medicine, allowing for real-time question and answer sessions [17]. Heart University is a website run by Cincinnati Children's Hospital Medical Center (CCHMC) that provides both pediatric and adult congenital heart disease content, primarily online videos of lectures with some testing capabilities [18]. The Congenital Heart Academy has had a variety of lecture series from world experts on particular pediatric cardiology topics with as many as 4000 attendees from around the world have participated in interactive question/answer sessions [19]. Large national organizations such as the American College of Cardiology and the American Society of Echocardiography have run successful virtual platform meetings since the onset of the COVID pandemic with interactive sessions and access to experts in the field. In our own institution, the Children's Hospital of Philadelphia (CHOP), we have developed online lectures on pediatric cardiology topics in the CHOP Online Pediatric Education Network [20].

Additional educational technology relevant to pediatric cardiology learners includes echocardiography simulators and 3D and virtual reality content. Some pediatric cardiology training programs have started to use simulation for training of echocardiography skills, especially in the COVID era, where use of volunteers is prohibited by social distancing measures. Use of echocardiography simulation has proven to be effective in both pediatric and adult cardiology training [21–23]. In addition, virtual reality (VR) has become a new and innovative teaching tool used by doctors at Stanford University to teach about congenital heart defects using computer created models [24]. VR has also been utilized to teach cardiac anatomy from real heart specimens using high resolution photogrammetry technique to create 3D interactive heart models that can be viewed online or in virtual reality (Fig. 1) [25]. This innovative modality, created by a collaboration with CHOP and CCHMC, may eventually do away with the need for cardiac specimens and will not be at risk for degradation. VR fits many of the learning preferences of our current generation of learners, being online, interactive with the ability to provide instant feedback and track progress. It has the additional benefit of being well suited to the three dimensionality of our field of congenital heart disease [26].

7. Conclusion

Medical education has gone through many iterations over the centuries. Traditional techniques including bedside teaching, shadowing, didactics, and clinical rounds will always have a role in medical training. Technology based education has many advantages in the current world climate providing universal, asynchronous, easily updatable, and sharable content in a format preferred by today's learner. As contemporary educators, we are compelled to provide content that is interactive, provides instant feedback, and most importantly, is shown to be effective by assessment of learner knowledge and application to patient care. While pediatric cardiologists have made great strides in reaching our current generation of medical trainees using technology in education, we have room to grow in incorporating the latest educational framework to target our rising generation of medical trainees [27]. Approaching development of new educational content with this purpose can help frame curriculum development and assessment in a scientific manner [28]. This is the future of medical education in pediatric cardiology and all other disciplines.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to

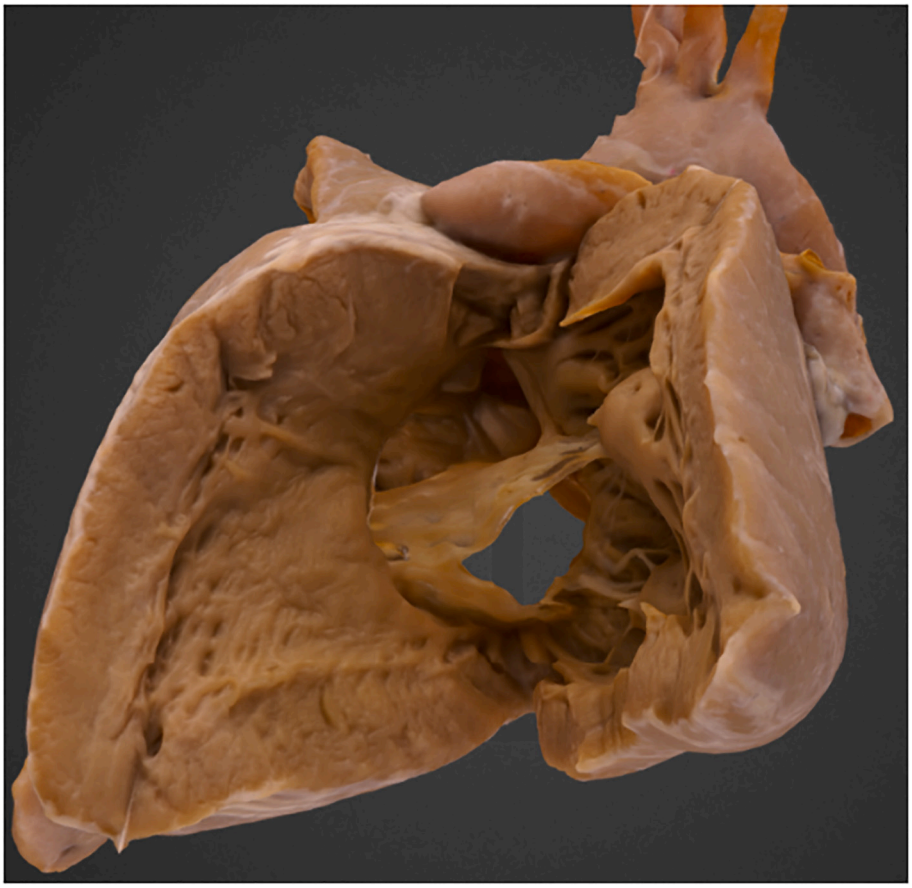

Fig. 1. Three-dimensional digital rendering of heart specimen created using photogrammetry technology from actual heart specimen. Specimen shows left ventricular view of a complete common atrioventricular canal defect. The common atrioventricular valve has two orifices, an unusual finding with a large ventricular septal defect. The interactive website allows for point and click explanations of anatomic landmarks.

influence the work reported in this paper.

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