http://doi.org/10.17576/apjitm-2022-1101-01
Asia-Pacific Journal of Information Technology and Multimedia
Jurnal Teknologi Maklumat dan Multimedia Asia-Pasifik
Vol. 11 No. 1, June 2022: 01 - 11
e-ISSN: 2289-2192

Received: 20 May 2021
Accepted: 21 October 2021
Published: 30 June 2022

A REVIEW OF MULTIMEDIA USAGE IN EMBRYOLOGY EDUCATION

RAZIF ABAS
SITI FADZIYAH MOHAMAD ASRI
AZMAH SAAT
NURUL HUDA MOHD NOR
RAFIDAH HOD
DINNA N. MOHD NIZAM
NOORKARDIFFA SYAWALINA OMAR

ABSTRACT

Embryology, which is a part of anatomy curriculum, is well known to be most difficult to teach. Applied embryology is important in medical practice especially in obstetrics and gynecology. To support teaching embryology, a few multimedia methods have been introduced for the past twenty years, such as animations, two-dimensional illustrations, three-dimensional illustrations, movies, and video. Innovative anatomy teaching and learning technology, particularly in the embryology syllabus, dramatically boosts students' understanding and interest while also indirectly simplifies anatomists' job. Students are excited to be able to visualize the embryo changes at any gestational age from fertilization to fetus development. Students' motivation is increased, and their comprehension and memorization are improved. In this review, we elaborate on the details of multimedia methods used for embryology teaching and learning as an alternative to traditional lectures and tutorials. The variety of approaches aids in reducing boredom and maintaining high levels of concentration. As a result, the multimedia usage is useful for long-term memorization.

Keywords: anatomy education, human embryology, multimedia approach, teaching and learning

INTRODUCTION

Generally, the medical curriculum comprises of preclinical and clinical phases. During the two or three years of the preclinical phase, medical students are required to complete the subjects of anatomy, physiology, biochemistry, pharmacology, and microbiology. Among these subjects, anatomy is considered to be the 'king of medical sciences'. Anatomy curriculum includes gross anatomy, microscopic anatomy (or histology), comparative anatomy, and developmental anatomy (or embryology) (Darda 2010). Traditionally, gross and microscopic anatomy are delivered as theory and practice, however, there is no practical session for embryology. The lack of visualization in embryology teaching usually dampened the medical students' interest hence the consistently high failure rate during the examinations (Al-Neklawy 2017).

First-year medical students need to gain full knowledge of human development to optimally relate the upcoming systemic subjects. Until now, lack of multimedia exposure is considered a major challenge in the public universities in Malaysia which might be due to cost constraint. Lecturers usually use the traditional method to teach embryology: PowerPoint with diagrams.

Innovative technologies in anatomy teaching and learning, especially in the embryology syllabus, significantly improved the students' understanding and interest, and also indirectly simplified the anatomy teachers' delivery methods (Moraes and Pereira 2010). Students are thrilled to visualize the developmental changes in the intrauterine life at a specific gestational age from the fertilization stage up to the fetal formation. Furthermore, their motivations are

elevated, better comprehension is gained, and their memorization is optimized (Koscinski et al. 2019).

Proper knowledge of embryology is important in clinical practice (Varga 2017). Congenital anomalies or birth defects that are encountered in the practice require a thorough understanding of embryology to provide optimal management. Understanding organogenesis gives important clues to why anatomical variation occurs (Carlson 2002). The incidence of birth defects varies depending on the intensity of screening; asking for screening is one of the reasons the concerned patients consult their doctors.

Teratogenicity during fetal development is harmful. The doctors need to know the normal embryology and the effects of teratogenic agents on fetuses in-utero during their developmental process to help mothers conceive healthy offspring (Friedman 2010). Clinical embryology is also important to understand assisted reproduction which deals with oocytes, sperms, and embryos outside the body (Skory 2013). Embryological knowledge is also beneficial for reparative and regenerative medicine, and also helps to understand certain disorders like Hirschsprung disease (Slavikova et al. 2015).

The aim of this review is to identify the multimedia approaches in embryological education. We compiled a list of all multimedia techniques to foster better understanding of teaching and learning in embryology.

ANIMATION

Animation is an art that has been around for some time and is vastly improving in the last century. Animation is a series of images or drawings that are arranged in a sequence or keyframe that creates motion illusion (Pikkov 2010; Wells 2013). It has been associated with a range of innovative forms and techniques, such as painting, scratching, hand-drawing, and computer graphics (Harris, Husbands, and Taberham 2019).

The application of animation in medical education has flourished in recent years, especially with the help of computer technology (Brown et al. 2020; Erolin 2019). A study showed preliminary evidence of animation efficacy among medical students in emergency medicine education (Zheng et al. 2017). Another study looked at the use of animation techniques in biochemical process among fifty students which improved understanding and learning interest (Joshi 2016). The development of animation used in embryology education among medical students has taken place due to the dissatisfaction with the current teaching method (Patel, Maleki, and Kulkarni 2018).

A study showed post-test scores of cardiovascular embryology animation, as in Figure 1, were significantly higher as compared to its pretest scores (Upson-Taboas, Montoya, and O'Loughlin 2019). Yet another study investigated the use of 2D animation in an embryology course to understand how different types of learners improve their learning in a regular classroom environment (Narayanan and Ananthy 2018). These studies show that there is a lot of room for research in the field of animation and embryology education.

During the third and fourth weeks of intrauterine development, the intricate event of gastrulation and neurulation may be advantageous for animation. Because these procedures entail several embryo folding, the animation would make the difficult or hidden aspect of the process more visible to the audience. Furthermore, the consequences of the changes in embryo development labeling will be easy to see. Embryology animations illustrating organ formation and growth, such as the brain and spinal cord, are also beneficial.

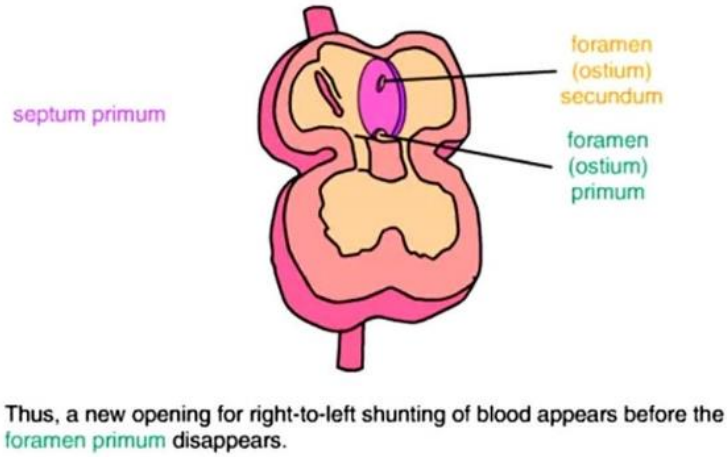

FIGURE 1. Examples of animation approach on human embryology learning. Development of cardiac chambers and septa is shown to improve students' knowledge scores.

ILLUSTRATION

A two-dimensional (2D) illustration somehow showed a better cognitive insight as compared to 3D (three-dimensional) which manifests 3D overload. Shapes and deformation of the embryonic development from fertilization to birth, as in Figure 2, were visualized as teaching material to the students (Kakusho et al. 2001). However, a few limitations were encountered by the students especially to imagine the deformities and teratology effects from each part of the embryo.

A study showed a simple 2D delivery method enables the promotion of educational learning and understanding but less effective for its learning outcome (Duenas and Lee 2018). In this study, pre and post quiz for the 2D and 3D groups were analyzed; the 2D group preferred the brighter colors and labelling whereas the 3D group a better dimensionality. However, both groups showed a significant outcome on the quizzes values as compared to no illustration delivery method.

There are few illustrations that show the findings of comprehensive embryological research of midgut development. Until now, the perplexing spectrum of midgut "malrotations" has been widely attributed to a "impaired" midgut rotation process. In general, the lack of trustworthy pictures of these critical embryological events in most of the articles is a flaw. The schematic representation of the rotation process might be a beneficial in animation. The reason for this is that most descriptions of midgut embryology were written in order to better understand the backdrop of malrotation pathophysiology rather than to describe midgut embryology.

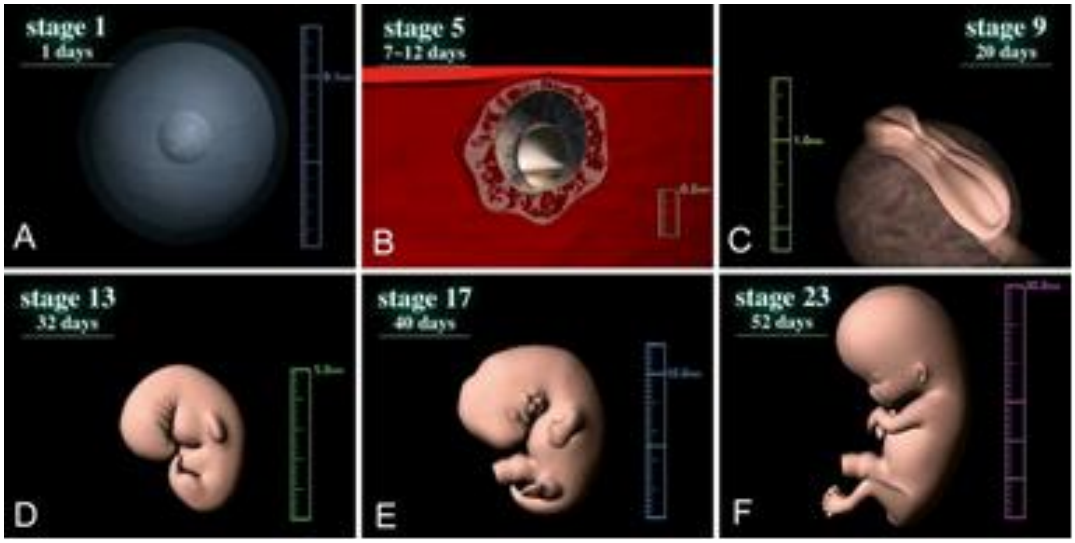

FIGURE 2. Examples of illustration approach on human embryology learning. From fertilization through birth, shapes and embryonic development.

AUGMENTED REALITY (AR)

AR involves a camera and screen where digital models are merged or superimposed into the real world. Screen refers to a screen of a digital device such as a smartphone or a tablet. The 3D AR object, which allows user interaction such as rotation, zooming in, and out will encourage and help the user to understand the structures from various angles, almost as real as holding an actual embryology structure. This is most useful for students who struggle to visualize complex anatomical structures from various angles (Brewer et al. 2012; Marsh, Giffin, and Lowrie Jr 2008).

A study showed AR Embryo Atlas, as in Figure 3, increased interest and enjoyment subscale as well as value and usefulness in first-year psychobiology students in the University of Amsterdam (Hillenius 2018). Although using AR modalities enhanced students' engagement and promotes higher participation, it did not increase their test scores (Moro et al. 2017). At present, though feedback from students is very encouraging, students do not think AR should replace traditional anatomy teaching completely, but rather as an adjuvant to existing practices (Kugelmann et al. 2018).

Along with traditional resources, AR is a promising technique for enhanced learning and memory of anatomical variances. AR could also be utilized in the classroom to teach complicated anatomy subjects. As a result, the text's descriptive information is strongly linked to supporting visual information, minimizing cognitive strain. In clinical practice, it could be valuable for patient education as well as a more time- and cost-effective way of planning complex surgical situations than existing 3D printing of models.

FIGURE 3. Examples of AR approach on human embryology learning. In first-year psychobiology students, AR boosted interest and enjoyment subscales as well as value and utility.

VIRTUAL REALITY (VR)

Traditionally, the teaching of human embryology depends on textbooks and lectures, with the addition of 2D images, models, and preserved human embryos. However, the new generation of undergraduate students is comfortable to the use of information technology (IT) for educational purposes. Therefore, the students' perceptions towards the virtual reality (VR) learning tool are a major determinant in utilizing the VR system to aid in understanding the human embryo's anatomical evolution.

A study showed that students who have had a previous VR experience have the benefits in VR embryology course materials, as in Figure 4 (Moraes and Pereira 2010). In medicine, VR technology expedites teaching and diagnostic activities such as surgical procedures, medical therapy, preventive medicine, patient education, medical education and training, skill enhancement and rehabilitation, visualization of massive medical databases, and architectural design for healthcare facilities (Dimitropoulos, Manitsaris, and Mavridis 2008). VR teaching methods assist students to explore the human body and create a 3D mental picture of human body structures. The enhancement of VR interactive environment for embryology teaching aid had improvised visualization, increased flexibility of the learning process, reduced time and effort needed, and made learning enjoyable (Alfalah et al. 2019).

On the basis that it offers stereoscopic vision, viewer-centered perspective, large angle of view, and interactively, VR technology was recommended to better visualization of three-dimensional structures over traditional media. The development of male and female genitalia, for example, is better visualized via VR since it shows the subtleties of gonadal development.

FIGURE 4. Examples of VR approach on human embryology learning. During the fourth week of embryonic life, the embryo is in the early stages of development. The model can be rotated and zoomed in all directions to see it from multiple perspectives and to visualize the 3D spatial layout of the structures.

MOVIES AND VIDEO

Several studies have documented the use of multimedia in the teaching of embryology (Holterman et al. 1999; Moraes et al. 2017; Nieder and Nagy 2002; Yamada et al. 2006). *In vitro* fertilization video was presented to first year medical students and the results were significantly positive – the students gained more interest and showed improvement in examination performance as shown in Figure 5 (Koscinski et al. 2019). A group of researchers developed a movie animation of embryo development and developed a program that allows the students to study human embryology in an engaging manner (Yamada et al. 2006). However, the study did not evaluate the use of the program among medical students.

Another study demonstrated the use of materials developed from the multimedia stores, which includes various videos, simulations, pictures, and previous clinical cases that provide history related to human embryology in the hope to better appreciate the conditions related to birth anomalies (Moraes and Pereira 2010). The students were assessed through behavioral questionnaires, interviews, and examination; after following the teaching of embryology using multimedia approaches, the students performed better in the examinations. Furthermore, this study also concluded that by using multimedia, students were better able to integrate the knowledge between the pre-clinical and clinical disciplines.

Human embryology is considered a difficult subject as students need to understand the process, time, and duration of the development. Furthermore, the terms used in this subject are notoriously tongue-twisters. As there are so many jargons and details to know, mere reading will not be able to accommodate students' need. Currently, the advancement of new information technology, especially video, has given rise to significant changes in teaching methods (McMillan 2001). The millennial generation is more familiar with digital devices than books. Many digital applications are easily assessed for educational purposes. To increase

understanding, instead of the time-consuming reading sessions, this millennial preferred to watch educational videos.

To adopt a more integrated approach to developing unified clusters of knowledge, skills, and attitudes, various methods are required. One of these methods is using video clips to supplement theoretical lectures (Mat Yudin et al. 2020). A study showed that higher marks were scored by the students receiving video clip input during theoretical teaching instead of full lecture (Pereira et al. 2004). The video clips apparently attract students' attention and encourage their understanding of complex anatomical connections and embryological processes.

Ostensibly, many facilities are needed to be provided by the university to accommodate proper teaching environment. This is one of the arguments against the use of video as part of the teaching and learning method. Poor lighting, unstable Internet connection, security of published material, possibility of virus attack, language barrier, and dubious quality of the video itself may also affect the teaching delivery (Mudge 1999). Despite the aim to get more understanding, students tend to lose focus and lecturers need to repeat the subjects using the traditional way.

Movies and videos can be constructed to depict any type of movement such as limbs development, by standardizing the initial image to the teacher's specific needs and projecting the end-point image using a animation software. It will not optimize the memorizing of embryology on its own because it delivers a large amount of knowledge in a short period of time.

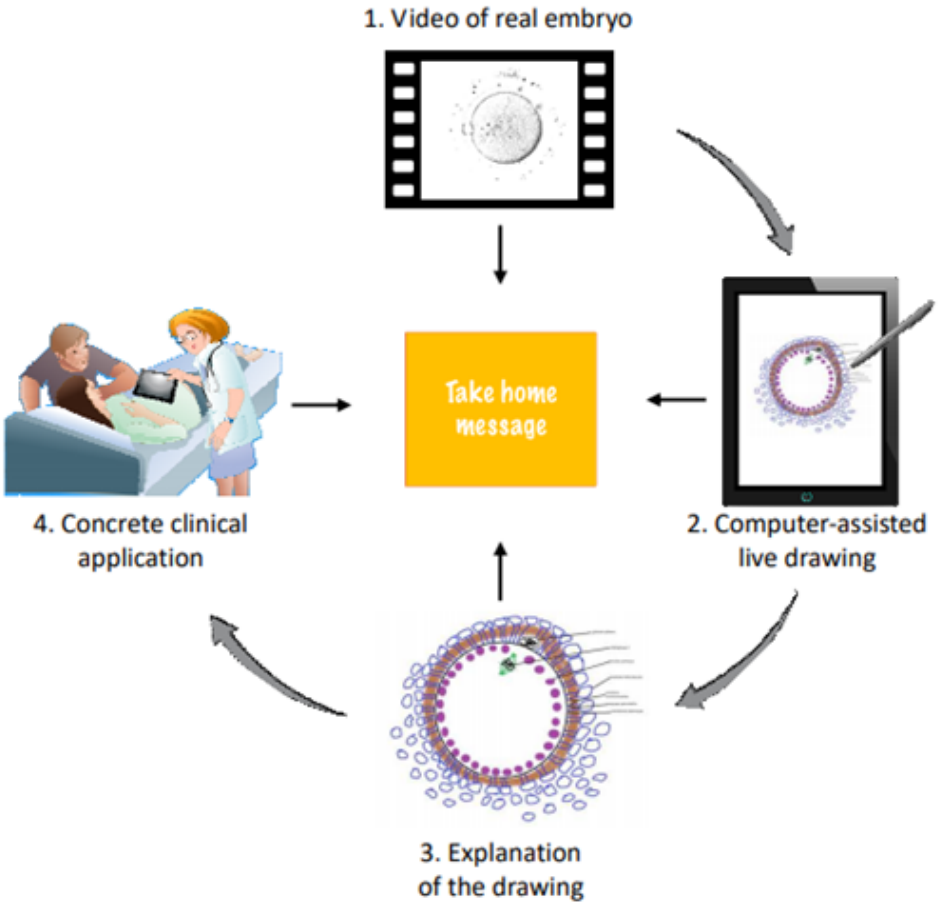

FIGURE 4. Examples of movie and video approach on human embryology learning. The process of in vitro fertilization was meticulously documented.

DISCUSSION

Embryology teaching and learning requires a certain amount of imagination since the formation of the specific organs or structures are complicated. Medical students have a difficult time studying embryology and grasping its importance. Students' involvement has been recommended to be improved by introducing peer-teaching approaches, condensing teaching content, and enhancing clinical focus (Kazzazi and Bartlett 2017). Even though some topics are straightforward, certain organ development requires a detailed imagination, hence multimedia is helpful. For example, the process of gastrulation and neurulation during the third week of intrauterine life requires the students to visualize the detailed steps. The use of VR technology as a teaching aid would improve learning outcomes. VR appears to improve students' comprehension and memory of the content, resulting in improved performance on the assessment (Alfalah 2020).

Since it has sound and vision, the video demonstrates all the qualities of being multimedia, as it satisfies the two channels for processing information described by earlier research. This form of material offered the advantage of time flexibility and the ability to be repeated at any moment (Universitario 2016). Some of the organogenesis requires a step-by-step understanding. For example, the visualization of development of the heart and rotation of the gut are important to understand the formation of each heart chamber and the intestine. The visual sequences are vital in identifying their anomalies whenever the steps are inorganized. Students' motivation to study is increased when videos are shown in embryology classes, which leads to higher comprehension. However, videos will not improve memorization on its own because a video delivers a large amount of knowledge in a short period of time. Videos should be linked to an explanatory educational tool for optimal teaching (Koscinski et al. 2019).

Embryology knowledge in the preclinical years is very useful during the clinical years of medical students. New embryology teaching model that uses information technology should be developed to increase students' interest in learning, promote students' active learning capacity, and improve their learning effect (Chen and Hua 2017). Students can relate any malformation diagnoses based on their embryology knowledge. Modern treatment and updated equipment, for example *in vitro* fertilization, underlies the importance of embryology learning.

Some anatomy teachers are more occupied with gross and clinical anatomy which might cause a lack of interest in embryology teaching. Less depth in embryology teaching, for example molecular-associated development being omitted, reduces the question distributions during examination. In certain curriculum, embryology is only compulsory in medical schools, making it difficult for non-medical lecturers to teach this subject. The variety of techniques helps to minimize boredom and maintain high levels of attention. Hence, a variety of pedagogic multimedia tutorials, in addition to standard embryology lectures, are effective for long-term memorization (Koscinski et al. 2019).

Students in human embryology class must understand the simultaneous changes in embryos, but they often struggle to grasp the ideas and visualize the corresponding processes in three dimensions. A multimedia approach proved effective in addressing a major issue with many medical institutions' teaching methods: the lack of connection between basic sciences and clinical specialties. The use of a multimedia method aided knowledge transmission and dissemination while also allowing for the adoption of a new approach to embryology education. This teaching method could be utilized elsewhere to improve undergraduate or postgraduate education with certain modifications.

CONCLUSION

Knowledge in embryology, from fertilization to organogenesis, is important to medical students and medical personnel. Studying the complex intrauterine human development is a tedious learning process. A few innovations are being created to supplement the learning process which has been summarized in Figure 1 to Figure 5. By these innovations, we believe that all medical schools would achieve better learning outcomes especially in anatomy subject. Finally, the multimedia approaches demonstrated that it was effective in both teaching and understanding the complicated topic of human embryology. We can confidently state that the development of this methodology aided students and instructors, via using multimedia software.

ACKNOWLEDGEMENT

We would like to thank the Department of Human Anatomy, especially the Anatomy Unit, and medical students from the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. I acknowledge all the contributors for all their hard work in producing this review.

REFERENCES

Al-Neklawy, Ahmed Farid 2017. 'Online Embryology teaching using learning management systems appears to be a successful additional learning tool among Egyptian medical students', *Annals of Anatomy*, 214: 9-14.

Alfalah, S. 2020. 'The value of virtual reality technology in embryology education; objective and subjective outcomes', *International Journal of Psychosocial Rehabilitation*, 24: 4672-84.

Alfalah, SF, Jannat F Falah, Nadia Muhaidat, Mutasem Elfalah, and Orwa Falah. 2019. 'Investigating Learners' Attitudes Toward Virtual Reality Learning Environments in Embryology Education', *Modern Applied Science*, 13.

Brewer, Danielle N, Timothy D Wilson, Roy Eagleson, and Sandrine De Ribaupierre. 2012. "Evaluation of neuroanatomical training using a 3D visual reality model." In *MMVR*, 85-91.

Brown, Bryan, Catherine Gao, Donna Windish, Jeremy Moeller, Emilie O'Neill, and Sarita Soares. 2020. 'Becoming Clinician-Animators: a Toolkit and Pilot Study for Novel Animated Content Development in a Medical Education Curriculum', *Medical Science Educator*, 30: 977-88.

Carlson, Bruce M. 2002. 'Embryology in the medical curriculum', *The Anatomical Record*, 269: 89-98.

Chen, Xudong, and Xinyu Hua. 2017. 'Application of three dimensional teaching method in histology and embryology course', *Advances in Social Science, Education Humanities Research*, 101: 1327-31.

Darda, David M 2010. 'Observations by a university anatomy teacher and a suggestion for curricular change: Integrative anatomy for undergraduates', *Anatomical Sciences Education*, 3: 73-76.

Dimitropoulos, Kosmas, Athanasios Manitsaris, and Ioannis Mavridis. 2008. 'Building virtual reality environments for distance education on the web: A case study in medical education', *International Journal of Social Sciences*, 2: 62-70.

Duenas, Angelique Nicole, and Lisa MJ Lee. 2018. 'If a picture is worth a thousand words, is a 3D picture worth two thousand words? Assessing educational value of 2D vs 3D figures in embryology education', *The FASEB Journal*, 32: 635.11-35.11.

Erolin, Caroline. 2019. 'Interactive 3D digital models for anatomy and medical education', *Biomedical visualisation*: 1-16.

Friedman, Jan M 2010. 'The principles of teratology: are they still true?', *Birth Defects Research Part A: Clinical Molecular Teratology*, 88: 766-68.

Harris, Miriam, Lilly Husbands, and Paul Taberham. 2019. *Experimental animation: from analogue to digital* (Routledge).

Hillenius, Devin 2018. 'Augmented Reality aided learn-ing of human embryo anatomy: A study on motivation and us-ability', *Science*.

Holterman, Mark, Oladapo Ashiru, Ra-id Abdulla, Gregory Blew, Suresh Sundararajan, Seema Rao, and Jayant Radhakrishnan. 1999. 'Clinically relevant embryology: new approaches to education', *Pediatrics*, 104.

Joshi, PN 2016. 'Animation Technique: an Effective tool to Understand certain Biochemical processes like Biological Oxidation', *%J International Journal of Current Research Review*, 8: 30.

Kakusho, Koh, Shinobu Mizuta, Yutaka Minekura, Michihiko Minoh, Tomoko Nakatsu, and Kohei Shiota. 2001. "Illustrating human development by computer graphics for education in embryology." In *Proceedings of the International Conference on Computers in Education*, 412-15.

Kazzazi, Fawz, and Jonathan Bartlett. 2017. 'Condensing embryology teaching for medical students: can it be taught in 2 hours?', *Advances in Medical Education*

Practice, 8: 797.

Koscinski, I, K El Alaoui-Lasmaili, P Di Patrizio, and C Kohler. 2019. 'Videos for embryology teaching, power and weakness of an innovative tool', *Morphologie*, 103: 72-79.

Kugelmann, Daniela, Leonard Stratmann, Nils Nühlen, Felix Bork, Saskia Hoffmann, Golbarg Samarbarksh, Anna Pferschy, Anna Maria von der Heide, Andreas Eimannsberger, and Pascal Fallavollita. 2018. 'An augmented reality magic mirror as additive teaching device for gross anatomy', *Annals of Anatomy*, 215: 71-77.

Marsh, Karen R, Bruce F Giffin, and Donald J Lowrie Jr. 2008. 'Medical student retention of embryonic development: impact of the dimensions added by multimedia tutorials', *Anatomical Sciences Education*, 1: 252-57.

Mat Yudin, Zainab, Kamran Ali, Wan Muhamad Amir Wan Ahmad, Anisa Ahmad, Mohd Fadhli Khamis, Nur ʻAliya Brian Graville Monteiro, Zeti Adura Che Ab. Aziz, Roslan Saub, Tanti Irawati Rosli, and Aspalilah Alias. 2020. 'Self‐perceived preparedness of undergraduate dental students in dental public universities in Malaysia: A national study', *European Journal of Dental Education*, 24: 163-68.

McMillan, Paul J 2001. 'Exhibits facilitate histology laboratory instruction: student evaluation of learning resources', *The Anatomical Record*, 265: 222-27.

Moraes, Suzana Guimarães, Marta Vidigal de Andrade Reis, Marcos Fernando Santos Mello, and Luís Antônio Violin Pereira. 2017. 'The usefulness of autopsies as a tool for teaching human embryology', *Journal of Morphological Sciences*, 21: 0-0.

Moraes, Suzana Guimarães, and Luis Antonio Violin Pereira. 2010. 'A multimedia approach for teaching human embryology: Development and evaluation of a methodology', *Annals of Anatomy*, 192: 388-95.

Moro, Christian, Zane Štromberga, Athanasios Raikos, and Allan Stirling. 2017. 'The effectiveness of virtual and augmented reality in health sciences and medical anatomy', *Anatomical Sciences Education*, 10: 549-59.

Mudge, Stephen M 1999. 'Delivering multimedia teaching modules via the Internet', *Innovations in Education Training International*, 36: 11-16.

Narayanan, Suresh, and Vimala Ananthy. 2018. 'The influence of learning style in understanding analogies and 2D animations in embryology course', *Anatomy Cell Biology*, 51: 260-65.

Nieder, Gary L, and Frank Nagy. 2002. 'Analysis of medical students' use of web‐based resources for a gross anatomy and embryology course', *Clinical Anatomy*, 15: 409-18.

Patel, Chandni Rajesh, Aryan Maleki, and Sagar Kulkarni. 2018. 'Enhancing the learning experience of embryology for medical students', *Advances in Medical Education*

Practice, 9: 139.

Pereira, JA, A Merí, C Masdeu, MC Molina-Tomás, and A Martínez-Carrió. 2004. 'Using videoclips to improve theoretical anatomy teaching', *Eur J Anat*, 8: 143-46.

Pikkov, Ulo. 2010. "Animashopy; Theoretical Writings on the Animated Film." In.: Estonia: Estonian Academy of Arts.

Skory, Robin M. 2013. 'The Autonomy of Follicle Biology: Applying Ovarian Follicle Culture to Model Development, Differentiation and Transformation', Northwestern University.

Slavikova, T, L Zabojnikova, J Babala, and I Varga. 2015. 'An embryological point of view on associated congenital anomalies of children with Hirschsprung disease', *Bratislavske Lekarske Listy*, 116: 640-47.

Universitario, Torreón. 2016. 'Use of multimedia digital tools in the teaching-learning of Human Embryology subject in students of the Medicine Career of UNAN-Managua', *Revista Torreón Universitario*, 14: 144-20.

Upson-Taboas, Charity F, Ruben Montoya, and Valerie Dean O'Loughlin. 2019. 'Impact of cardiovascular embryology animations on short-term learning', *Advances in Physiology Education*, 43: 55-65.

Varga, Ivan 2017. 'Embryology teaching: An often-neglected part of the medical curriculum', *Revista Argentina de Anatomía Clínica*, 9: 47-51.

Wells, Paul. 2013. *Understanding animation* (Routledge).

Yamada, Shigehito, Chigako Uwabe, Tomoko Nakatsu‐Komatsu, Yutaka Minekura, Masaji Iwakura, Tamaki Motoki, Kazuhiko Nishimiya, Masaaki Iiyama, Koh Kakusho, and Michihiko Minoh. 2006. 'Graphic and movie illustrations of human prenatal development and their application to embryological education based on the human embryo specimens in the Kyoto collection', *Developmental Dynamics*, 235: 468-77.

Zheng, Huilong, Nicoletta Adamo-Villani, Tim McGraw, and Rosanne Griggs. 2017. 'Using computer animation for emergency medicine education', *International Journal of Technology Enhanced Learning*, 9: 354-68.

Razif Abas[1]*
Siti Fadziyah Mohamad Asri[1]
Azmah Saat[1]
Nurul Huda Mohd Nor[1]
Rafidah Hod [1]
[1]Department of Human Anatomy
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
43400 Serdang, Selangor, Malaysia
razifabas@upm.edu.my, fadziyah@upm.edu.my, azmahsaat@upm.edu.my,
hudamohdnor@upm.edu.my, rafidahhod@upm.edu.my

[*]Department of Anatomy and Embryology
Leiden University Medical Centre
23000 RC, Leiden
The Netherlands

Dinna N. Mohd Nizam[2]
[2]Faculty of Computing and Informatics
Labuan International Campus
Universiti Malaysia Sabah
87000 Labuan, Wilayah Persekutuan Labuan, Malaysia
dinna@ums.edu.my

Noorkardiffa Syawalina Omar[3]
[3]Department of Obstetrics and Gynecology
Faculty of Medicine
Universiti Teknologi MARA
Sungai Buloh Campus
47000 Sungai Buloh, Selangor, Malaysia
dyff80@uitm.edu.my