RESEARCH PAPER | Medical Science | Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

Assisted E-Learning Computer Program as a Teaching-Learning Resource on Human Embryology

KEYWORDS: embryology; assisted learning; e-learning; self-learning.

Dr. T Vijay Sagar
MBBS, MD (Anatomy) Professor and Head, Department of Anatomy, Sri Ramachandra Medical University, Chennai

Dr. S Viveka
MBBS, MD (Anatomy), DNB (Anatomy), Assistant Professor, Department of Anatomy, Azeezia Institute of Medical Sciences, Kollam

ABSTRACT *Objectives: The utility and reception of a self-explanatory, multimedia rich, e- learning computer application as an alternative resource for teaching-learning in human embryology was evaluated.*

Methodology: *After taking institutional ethics clearance and written informed consent, all first year medical undergraduate students were included in the study. An e-learning computer application on human embryology was prepared. A teaching faculty member was present during the e-learning session to assist in the learning process. The usefulness of this resource in embryology was assessed through Kirkpatrick's four levels of evaluation model. The results were compared with interval assessment results from the previous batch of students who were taught embryology via the traditional method of didactic lectures.*

Results: *Questionnaire analysis: 98% of students strongly agreed that the e-learning module was extremely beneficial for learning embryology. The mean score favouring this method in comparison to traditional methods was 4.58 (±0.65) out of scale 5. Interval assessment results: There was a significant improvement in mean scores from first to third assessment (from 3.7 to 5.88). Practical viva marks evaluating the students' ability to identify key structures in the museum specimens and models showed improvement. Comparison with previous batch: The study group showed a statistically significant improvement in performance as compared to the previous batch which was taught via the traditional teaching learning methods.*

Conclusions: *Student reception of assisted e-learning embryology program was excellent. It resulted in a better understanding and assimilation of embryology concepts as evidenced through theory and practical interval assessments. Though the process of preparing an e-learning module is laborious and time consuming, once prepared, the expert knowledge is captured for repeated use with subsequent batches. A multimedia rich e-learning program makes learning more interesting, interactive and immersive. Minor modifications in the e-program can be easily incorporated subsequently.*

Introduction:
Embryological basis of disease provides strong foundation of clinical knowledge. Most medical students get exposed to detailed learning of human embryology in their first year of medical education. The aim of embryology curriculum in medical education is to train medical graduates to understand the normal development of human body. This knowledge can be applied subsequently in clinical terms to understand the embryological basis of various developmental anomalies. Most medical colleges in India rely on the traditional teaching learning method of didactic lectures to impart education in embryology. The learning process in embryology is assessed by short answer questions in both interval and summative assessments. Practical evaluation of students includes identification of various models on embryology and a viva voce.

However, the weightage given to embryology in summative assessments is relatively meagre, accounting for a paltry 5-7 % of the total marks in a theory exam. For such a less proportion of marks, a student has to go through voluminous learning material in a very short period. Learning embryology adds to heavy burden of gross anatomy and histology. Most students end up learning just a few topics only with exam point of interest. Eventually, the entire exercise undermines the learning objectives.

To address this issue, we evaluated a self-designed e-learning computer application as a study material for teaching-learning resource for human embryology. Similar computer assisted instructional material was evaluated by Foreman et al for teaching neuroanatomy and opined that if the study material is of proper design and students need additional resources, then such an e-learning program will be a prodigious teaching-learning method for medical undergraduates[1]. Computer assisted instructional material for teaching gross anatomy is increasing[2,3]" A desire by students to look out for study material outside routine cadaveric dissections and the visual nature of these is creating an increasing need for such computer assisted material. Assisted e-learning material has been implemented in many courses and is making a meaningful impact in learning patterns of current students[4–11]the education on PrUs is mainly based on traditional lecturing, seminars and face-to-face instruction, sometimes with the support of photographs of wounds being used as teaching material. This traditional educational methodology suffers from some important limitations, which could affect the efficacy of the learning process. This current study has been designed to introduce information and communication technologies (ICT. Such material is used to supplement existing traditional methods of dissections[12], histology demonstrations[13,14] and neuroanatomy lectures[1]. Many instructional materials can be provided with e-learning.[15–17]. Prabably, the greatest advantage of e-learning is that it provides an opportunity for real-time learner interactivity[18]. Apart from this, the graphical and visual contents can be effectively and efficiently delivered to user end via e-learning programs[19].

Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

Methodology:
An assisted e-learning computer application emphasising all major and minor topics of undergraduate medical human embryology was designed and executed. The e-learning program was made with the help of a rapid authoring tool "knowledge presenter" version X. The executable application can be used on desktop computers or laptops with Microsoft Windows 7 & 8 operating systems.

(a) Software description: The software graphical user interface screen (GUI) shows a large display area in the centre and navigation menu on the left side where chapter headings and subheadings are listed. Each topic in chapter has relevant key text highlighted on the right side of the display area with relevant diagrams and videos on the left side. In addition, each topic has audio narrations. Tool bar for audio controls are placed at the bottom. A learner can replay the topic or navigate from each page.

(b) Description of content:
Text: Only key words and short sentences, most relevant to the topic under consideration are displayed. In a few slides, the most important text is made to blink to highlight its importance.

Illustrations: Relevant diagrams were created using computer software like Microsoft paint, corel draw and adobe illustrator. Most diagrams were created in such a way that students could easily reproduce them. Unnecessary details and shades were avoided in all possible locations (Figure 1)

(c) Audio narrations: The audio narration script was written in simple english avoiding the complex jargon of vocabulary. Short sentences were used in commentary. Audio recording was done by using Audiotechnica computer interface device. Post recording processing was conducted on Audacity software.

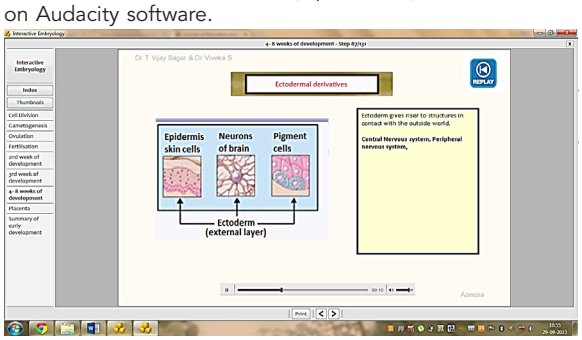

Figure 1: Screenshots of assisted e-learning program on embryology.

(e) Lecture hand-outs: All classroom interactions were preceded by distribution of lecture hand-outs of approximately 3-6 pages per lesson. Handouts contained both text and diagrams. The same diagrams were also used in the e-learning program.

The study was undertaken after institutional ethics committee clearance. All first year medical students consented for the study. Students were exposed to the e-learning study application from the beginning of first year of course. All embryology lecture classes were conducted using this application. The lessons were projected on the screen using the computer projection system. Audio narrations were routed from the computer to the amplifier in the lecture theatre. At-least one teaching faculty was present in the lecture theatre during the e-learning session to assist the learning process by reinforcing the concepts under consideration. Such sessions were held throughout the academic year. Traditional didactic lectures were completely done away with.

The utility and effectiveness of the e-learning program was assessed through (a) feedback questionnaire (b) Interval assessments (c) Practical viva marks.

The questionnaire addressed issues of navigational ease, clarity of images and benefits of assisted e-learning and rating of this e-learning resource in comparison to traditional teaching methods. Ideas from previous researches were used to build up the feedback questionnaire[17,20]The results were compared to data from previous batch where students were taught embryology as per the traditional didactic lectures.

All results were tabulated and statistically evaluated. The data in the form of marks obtained was expressed as mean values with standard deviations. Values from the present batch (study group) and the previous batch (control group) were compared with the help of Students 't' test. A p value of less than 0.05 was considered as significant.

Results:
All first year medical undergraduate students participated in the study and formed the study group. There were 62 females and 38 males in the batch. The mean age of students was 18.2 (±1.2) years. The students from the previous batch of I MBBS who were taught embryology via traditional teaching methods formed the control group.

Questionnaire results:
Approximately 82% students opined that navigation in assisted e learning tool was easy; 79% students felt that drawings used in the e-learning application were clear; 54% students felt that these drawings could be easily reproducible in their notes and examinations. 92% students opined that language used throughout the program was clear and lucid. 72% of students felt that the e-learning resource was extremely helpful in understanding the complex developmental processes in embryology. About 46% of students felt that it was very helpful in revision. An overall 98% students strongly agreed that the e-learning embryology module was a highly innovative, interactive and useful method of learning embryology. About 64% students opined that the computer based e-learning module was much better than traditional method of didactic lectures. The mean score favouring the e-learning resource in comparison to the traditional didactic lecture was 4.58 (±0.65) out of scale 5 (table 1).

Table 1: Questionnaire results. used to get level 1 reaction from students (n=100)

Question	Strongly disagree	Strongly agree	Mean scores (± SD)
Diagrams used in the e-program are clear	1	5	4.36±0.94
Diagrams are easily reproducible	1	5	3.91±1.37
Navigation within e-program is easy	1	5	3.22±1.4
Content and Language are user friendly.	1	5	4.41±0.98
E-program helped to understand the concepts in embryology	1	5	3.45±1.38

Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

E-program is beneficial in revisomg concepts in embryology	1	5	2.58±1.51
E-program is much better than traditional teaching learning methods.	1	5	4.580±0.65

Interval assessment results:
All students attended the three interval assessments. Internal assessment papers contained questions from Gross anatomy, histology and embryology. The internal assessment paper was marked for 50 marks out of which 10 marks were allotted for questions on embryology. Table 2 shows compilation of results. There was a significant change in low performance students (60 in first and 14 in third assessments). In third assessment, 22 students scored more than eight marks. There was a significant improvement in mean scores from first to third assessment (from 3.7 to 5.88).

Table 2: Performance of students in theory interval assessments held at regular intervals throughout the year

	Less than 5 marks out of 10	5 to 8 marks out of 10	More than 8 marks	Mean score ± SD (out of 10) (n=100)
Ist assessment	60	34	6	3.7 ± 2.28
IInd assessment	32	54	14	4.95±2.31
IIIrd Assessment	14	64	22	5.88±1.85

Practical viva marks evaluating students' ability to identify key structures in the museum specimens and models showed improvement (Table 3). Students' ability to reconstruct the key concepts in embryology using clay in groups was well appreciated.

Table 3: Performance of students in practical viva Ist, IInd and IIIrd interval assessments held at regular intervals throughout the year

	Less than 5 marks out of 10	5 to 8 marks out of 10	More than 8 marks out of 10	Mean score ± SD (out of 10) (n=100)
Ist assessment	82	16	2	2.92 ± 2.05
IInd assessment	45	53	2	4.1±1.86
IIIrd Assessment	36	58	6	6.74±1.42

Comparison with previous batch (study group vs control group):
The previous batch of medical undergraduate students included 58 females and 42 males. Their mean age was 18.5 (±1.3) years. According to their performance students were divided into 3 groups – Group A had students securing less than 50 % marks (poor performers), Group B had students who secured 50 to 65 % (average performers) and Group C had students who had secured more than 65 % marks (good performers). The scores of these groups were compared to similar groups in the present batch (study group) (Table 4). There was a statistically significant improvement in scores of average performers category and good students category in present batch after imparting knowledge via the e-learning module. There was no difference in performance of poor students. On an overall basis, the class average of current batch was significantly higher than the previous batch (4.89 vs 4.32, $p<0.05$).

Table 4.

	Previous batch			Student t test			Current batch		
	Mean ± SD = 4.32±0.12			p value			Mean ± SD = 4.89±0.5		
	Gr A	Gr B	Gr C	Gr A	Gr B	Gr C	Gr A	Gr B	Gr C
Mean	0.76	5.47	6.72	0.32	0.00003	0.00001	1.2	5.88	7.6
SD	0.72	0.46	0.59	Not significant	Significant	Significant	1.31	0.64	0.33

Twelve students proposed a few improvements to the existing e-learning resource in their feedback form. Students preferred animations over static pictures. Some suggestions were to have quiz at the end of each topic; to provide web links for further details at the end of topics; and provide clinical case examples for better correlation of abnormalities.

Discussion:
The reduction of time frame for I year MBBS course without a corresponding reduction in the syllabus has resulted in a severe time constrain for the teaching faculty in completing the syllabus. This also translates into a very heavy academic burden for the students. Since weightage to embryology is meagre, most students usually study a few topics in embryology purely from an examination point of view. Very few students have a full grasp of embryology and its application in the clinical field.

Computer based teaching-learning methods are widely gaining acceptance all over the world. Today, students, researchers, teaching faculty are increasingly making use of the tremendous advantages offered by e-learning to learn, teach and collaborate more effectively than ever before. The advent of rapid authoring tools like knowledge presenter, Adobe articulate, Instructure, Blackboard etc have come to the rescue of instructors who are not familiar with computer programming knowledge. With a little basic training on these rapid authoring tools, most trainers can make professional looking, highly effective e-learning material which can be deployed over the internet, intranet or delivered via a CD or DVD-ROM. E-lessons can be made very interactive by judicious use of pictures, animations, audios and videos. The wide availability of internet and abundance of handheld devices which can access internet has resulted in a highly conducive environment for interactive and engaging e-learning.

The present e-learning module was prepared with the help of a rapid authoring tool. The program was designed to provide concepts of embryology in a simple manner with plenty of illustrations and animations. The cognitive load was kept relatively low with the main effort directed towards the key conceptual areas. Audio narrations were extensively used throughout the program. In addition to providing highly engaging and interactive content, the same module can be delivered to the students via a web based portal or via CD/DVD ROM. Such resources offer tremendous advantages in terms of flexibility and availability. The modules can be accessed 24 X 7. Students can revise the topics at their own pace and time.

Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

In the present study, the utility and effectiveness of assisted e-learning resource on embryology was conducted by Kirkpatrick's four levels of evaluation model.

At Level 1, the reactions were assessed by feedback forms administered at the beginning and termination of the course. A large percentage of students found the e-learning module highly innovating, interactive, engaging and more preferable to the traditional didactic lectures on embryology. As in most forms of e-learning, providing the content in the form of an e-lesson prior to a class can help free up more classroom time for interactive sessions with students.

At Level 2, learning process was assessed by series of three interval assessments along with other topics. Students' performance in embryology in these assessments were tabulated and compared with results from the previous batch which was taught embryology via the traditional didactic lectures. While the e-learning program did not help the poor performers in the study group, the average performers and good performers showed a statistically significant improvement in performance when compared to students forming the control group.

Level 3, behavioural changes were assessed by performance of students in practical viva exam and by group activities. In group activities, students were asked to reconstruct key embryological concepts using clay models. Their ability to apply basic concepts in a 3 dimensional workspace was assessed. The three internal assessments showed a steady shift of significant numbers of students from the less than 50% marks group to upper groups, thus showing the benefit of the e-learning module in embryology.

Most of medical e-learning tool evaluation research concentrates on perceivable outcomes[21–26]all entering PT students (n = 18. Foreman and David evaluated the design of a web-based computer assisted instructional tool for neuroanatomy self-study[1]. Their evaluation showed that if the design of e-learning tool is not versatile and the content is not easily reproducible, a learner may not use such tools in his learning process.

Transfer of knowledge is possible only if there is sufficient interaction between the learner with the interface or content[27]. In the e-learning program on embryology, there is constant learner/interface and learner/content interaction in every frame. A learner can opt for replay or proceed to next topic based on his level of understanding of the concepts.

The design of the present e-learning program on embryology was conducted as per principles highlighted in Mayer's Cognitive Theory of Multimedia Learning (i.e. Generative Theory)[28]. The content is presented in learner paced segments rather than continuous unit (segmentation principle). The Learning process is better from animation and narration than from animation and on-screen text (Modality principle). On-screen text provided on right side panel in AEE matches audio narration played (Redundancy principle). Key words are presented both in text panel and in diagram panel (Signalling principle).

Many factors influence student's acceptance of an e-learning tool. First, its interface needs be simple, self-explanatory and interactive. Dubuis-Grieder studied what factors accentuated interest in a course and concluded that it is not always e-learning platform29 which makes the difference. Perception of use by students also is a factor which accentuates interest. The technology acceptance model (TAM) developed by Davis demonstrates that the adoption of a technology by students based on the computer is explained by the perceived ease of use and the perceived usefulness30. We believe that there is perceived need for a better teaching- learning resources on human embryology. e-learning applications such as the one prepared during this study address this need and provide an interactive, interesting and immersive learning experience for students.

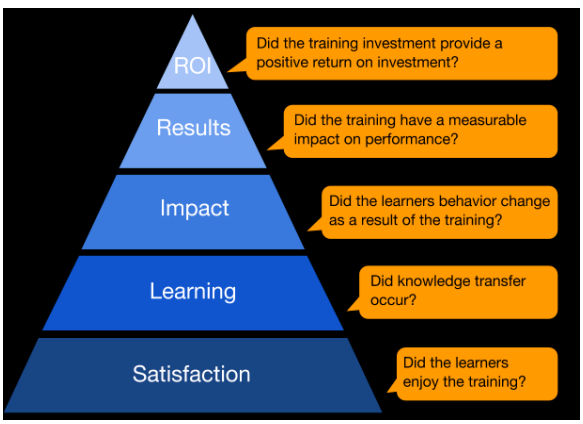

Table 1: Questionnaire used to get level 1 reaction from students (n=100)

Question	Strongly disagree				Strongly agree	Mean scores (± SD)
Drawings used in the AEE tool are clear	1	2	3	4	5	4.36±0.94
Drawings can be drawn in your notes during learning	1	2	3	4	5	3.91±1.37
AEE tool is easy to navigate	1	2	3	4	5	3.22±1.4
Language and accent is understandable	1	2	3	4	5	4.41±0.98
AEE tool helped you to understand the concepts in embryology	1	2	3	4	5	3.45±1.38
AEE tool is beneficial to revise concepts in embryology	1	2	3	4	5	2.58±1.51
AEE tool is overall beneficial	1	2	3	4	5	4.05±0.64

Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

Rate AEE tool in comparison to traditional teaching methods Much better than traditional methods Somewhat better than traditional methods Same as traditional methods Worse than traditional methods Much worse than traditional methods						4.580±0.65

Table 2: Performance of students in theory interval assessments held at regular intervals throughout the year(n=100)

	Less than 5	5 to 8	More than 8	Mean score ± SD (out of 10)
Ist	60	34	6	3.7 ± 2.28
IInd	32	54	14	4.95±2.31
IIIrd	14	64	22	5.88±1.85

Table 3: Performance of students in practical viva interval assessments held at regular intervals throughout the year(n=100)

	Less than 5	5 to 8	More than 8	Mean score ± SD (out of 10)
Ist	82	16	2	2.92 ± 2.05
IInd	45	53	2	4.1 ± 1.86
IIIrd	36	58	6	6.74 ± 1.42

Table 4: Comparison of marks of previous batch and current batch students in embryology section in interval assessments(n=100 in both batches)

	Previous batch			Student t test			Current batch		
	Mean ± SD = 4.32±0.12			P value			Mean ± SD = 4.89±0.5		
	Poor	Pass	Good	Poor	Pass	Good	Poor	Pass	Good
Mean	0.76	5.47	6.72	0.32	0.00003	0.00001	1.2	5.88	7.6
SD	0.72	0.46	0.59	Not sig	significant	Significant	1.31	0.64	0.33

REFERENCE

1. Foreman KB, Morton DA, Musolino GM, Albertine KH. Design and utility of a web-based computer-assisted instructional tool for neuroanatomy self-study and review for physical and occupational therapy graduate students. Anat Rec B New Anat. 2005 Jul 1;285B(1):26–31. 2. Berube D, Murray C, Schultze K. Cadaver and Computer Use in the Teaching of Gross Anatomy in Physical Therapy Education. J Phys Ther Educ. 1999 Oct 1;13(2):41. 3. McNulty JA, Halama J, Dauzvardis MF, Espiritu B. Evaluation of Web-based computer-aided instruction in a basic science course. Acad Med J Assoc Am Med Coll. 2000 Jan;75(1):59–65. 4. Veredas FJ, Ruiz-Bandera E, Villa-Estrada F, Rufino-González JF, Morente L. A web-based e-learning application for wound diagnosis and treatment. Comput Methods Programs Biomed. 2014 Oct;116(3):236–48. 5. Citak M, Haasper C, Behrends M, Kupka T, Kendoff D, Hüfner T, et al. [A web-based e-learning tool in academic teaching of trauma surgery. First experiences and evaluation results]. Unfallchirurg. 2007 Apr;110(4):367–72. 6. Hassan BA, Jacobs R, Scarfe WC, Al-Rawi WT. A web-based instruction module for interpretation of craniofacial cone beam CT anatomy. Dento Maxillo Facial Radiol. 2007 Sep;36(6):348–55. 7. Stausberg J, Bludssat K, Geueke M. Completeness and accuracy of WWW-based catalogues of medical E-learning modules. Med Inform Internet Med. 2005 Sep;30(3):195–202. 8. Al-Rawi WT, Jacobs R, Hassan BA, Sanderink G, Scarfe WC. Evaluation of web-based instruction for anatomical interpretation in maxillofacial cone beam computed tomography. Dento Maxillo Facial Radiol. 2007 Dec;36(8):459–64. 9. Ridgway PF, Sheikh A, Sweeney KJ, Evoy D, McDermott E, Felle P, et al. Surgical e-learning: validation of multimedia web-based lectures. Med Educ. 2007 Feb;41(2):168–72. 10. Yang A, Goel H, Bryan M, Robertson R, Lim J, Islam S, et al. The Picmonic(®) Learning System: enhancing memory retention of medical sciences, using an audiovisual mnemonic Web-based learning platform. Adv Med Educ Pr. 2014;5:125–32. 11. Kölling J, Langenkämper D, Abouna S, Khan M, Nattkemper TW. WHIDE--a web tool for visual data mining colocation patterns in multivariate bioimages. Bioinforma Oxf Engl. 2012 Apr 15;28(8):1143–50. 12. The Visible Human Project: a resource for education. : Academic Medicine [Internet]. LWW. [cited 2015 Jul 28]. Available from: http://journals.lww.com/academicmedicine/Fulltext/1999/06000/The_Visible_Human_Project__a_resource_for.12.aspx 13. Sagar V. Human Histology. e-learning course on DVD. New Delhi: Infomed; 2012. 14. Course on Human Histology [Internet]. SmarTeach. [cited 2015 Jul 28]. Available from: http://www.smarteach.com/course/course-on-human-histology/ 15. Clark RC, Mayer RE. E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning [Internet]. John Wiley & Sons; 2011 [cited 2015 Jul 28]. Available from: https://books.google.co.in/books?hl=en&lr=&id=twoLz3jlkRgC&oi=fnd&pg=PA1&dq=e-learning+material+instructional+material+&ots=MeA9mkWDmj&sig=5fHRbkamPRPvWRNAnUA44v-iprQ 16. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of e-learning in medical education. Acad Med. 2006;81(3):207–12. 17. Zahnd J, Rueger D, Gurtner G. Pedagogical Aspects of Education in a VirtualClassroom. Conference on New Learning Technologies. University of Technique and Architecture of Fribourg, Switzerland; 1998. 18. Mayer RE. Multimedia learning [Internet]. Cambridge university press; 2009 [cited 2015 Jul 28]. Available from: https://books.google.co.in/books?hl=en&lr=&id=5g0AM1CHysgC&oi=fnd&pg=PR1&dq=e-learning+material+instructional+material+&ots=T9-BBq86ER&sig=VwpEDXHoQzyAVXVQKB84pa4O0WU 19. Zhang D, Zhou L, Briggs RO, Nunamaker JF. Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. Inf Manage. 2006;43(1):15–27. 20. Ragan L. Good Teaching Is Good Teaching: An Emerging Set of Guiding Principles and Practices for the Design and Development of Distance Education. CauseEffect J. 1999;22(1). 21. Bukowski EL. Assessment outcomes: computerized instruction in a human gross anatomy course. J Allied Health. 2002;31(3):153–8. 22. Fleming DE, Mauriello SM, McKaig RG, Ludlow JB. A comparison of slide/audiotape and Web-based instructional formats for teaching normal intraoral radiographic anatomy. J Dent Hyg JDH Am Dent Hyg Assoc. 2003;77(1):27–35. 23. Erkonen WE, Krachmer M, Cassell MD, Albanese MA, Stanford W. Cardiac anatomy instruction by ultrafast computed tomography versus cadaver dissection. Invest Radiol. 1992 Sep;27(9):744–7. 24. Devitt P, Palmer E. Computer-aided learning: an overvalued educational resource? Med Educ. 1999 Feb 1;33(2):136–9. 25. Stanford W, Erkonen WE, Cassell MD, Moran BD, Easley G, Carris RL, et al. Evaluation of a computer-based program for teaching cardiac anatomy. Invest Radiol. 1994 Feb;29(2):248–52. 26. Garg GN, Lawrence Spero, Ian Taylor, Amit. Learning anatomy: do new computer models improve spatial understanding? Med Teach. 1999 Jan 1;21(5):519–22. 27. Chou C. Interactivity and interactive functions in web-based learning systems: a technical framework for designers. Br J Educ Technol. 2003 Jun 1;34(3):265–79. 28. Jean-Eric P. E-Learning 2.0 Technologies and Web Applications in Higher Education. IGI Global; 2013. 415 p. 29. Hervé Platteaux R de F. How students perceive e-learning situations? The case of the SVC WBT embryology course. 2003; 30. Bagozzi RP, Davis FD, Warshaw PR. Development and Test of a Theory of Technological Learning and Usage. Hum Relations. 1992 Jul 1;45(7):659–86.