



## Original Research Article

## ‘Sequence graphics’ for gross anatomy diagrams and their objective evaluation

S Viveka<sup>1,\*</sup>, M J Sudha<sup>2</sup><sup>1</sup>Dept. of Anatomy, Azeezia Institute of Medical Sciences, Kollam, Kerala, India<sup>2</sup>Dept. of Pharmacology, Azeezia Institute of Medical Sciences, Kollam, Kerala, India

## ARTICLE INFO

## Article history:

Received 15-08-2020

Accepted 02-09-2020

Available online 10-09-2020

## Keywords:

Artistic anatomy  
Medical illustrations  
Drawings  
Sectional anatomy  
Graphics

## ABSTRACT

**Background and Objectives:** Drawing diagrams is an integral part of learning anatomy. The objective of the study was to evaluate sequence graphics to impart drawing skills among medical undergraduates. The other objective of the study was to design and evaluate an objective method of assessment of clinically relevant moderately complex gross anatomy diagrams.

**Methodology:** In an experimental study, participated by 92 students, were asked to draw coronal section of male pelvis (moderately complex diagram) projected on the board. The same diagram was redone with PowerPoint in such a way that each component appears sequentially on command from the teacher, technique called sequence graphics. Sequence labelling followed appearance of each component. The perineal membrane was the key component. Prostate gland (with urethra), deep transverse perineal muscle (with bulbourethral glands) and Colle's fascia were accessory components. Both diagrams were analyzed for the centeredness, appropriate color usage, bilateral symmetry, and representation of key and accessory components and labelling. Deviation of three accessory components of student images of more than one grid was considered as grossly disproportional diagram.

**Results:** Sequence graphics image scores were significantly more than the scores from projected image tracing ( $6.04 \pm 2.03$  vs.  $4.72 \pm 2.18$ ). The improvement was particularly in terms of symmetry, representation of key and accessory components, labelling and use of appropriate colors.

**Conclusions:** Sequence graphics resulted in drawings with predefined components with labelling. Defining key component and accessory components for moderately difficult diagrams shall result in objective evaluation. Sequence graphics principles aids better drawing skills.

© 2020 Published by Innovative Publication. This is an open access article under the CC BY-NC license (<https://creativecommons.org/licenses/by-nc/4.0/>)

## 1. Introduction

Drawing diagram is an integral part of learning anatomy. Often the marks scored by an undergraduate in both summative and formative assessments depends on the student's ability to convey the concepts schematically with a diagram. Of course, the objective of educational program in a medical school is not to make a learner good artist.<sup>1</sup> However, certainly a doctor who can explain complex medical concepts with a simplified diagrams and flow charts is well appreciated among patients and professional circles.<sup>2</sup> In the process of learning drawing skills, a fresh

entrant may follow many unscientific and unsound methods.

Many clinicians learnt the art of drawing from their teachers. Teachers of bygone era were brilliant in their black board drawing. However, with the modern methods of teaching learning the art of drawing is dwindling.<sup>3</sup> With the advent of presentation software, projector throws most information on the screen. Teaching anatomy goes with no exception. Students have to draw the diagram from the image shown on the screen.<sup>4</sup> Often learner will be in huge confusion as to where to start and how to proceed a complex diagram.<sup>5</sup> This leads to poor quality diagrams depiction in the classroom. For most students, classroom learning forms a first impression of the concept. Even the modern teaching learning methodology can fail to impart the intended skill of

\* Corresponding author.

E-mail address: [vivekabharathi@gmail.com](mailto:vivekabharathi@gmail.com) (S. Viveka).

drawing diagrams.

Many a times, the student will be in downward spiral encompassing poor concepts, improper diagrams and poor assessment scores.<sup>6,7</sup> There have been many attempts in the past to imbibe drawing skills among anatomy trainees. However, the existing technology is luring with easier ways of teaching learning.<sup>8,9</sup>

Drawing diagrams forms the crux of learning anatomy. Without simple and conceptualized two-dimensional representations of the complex structures, the learning of gross anatomy is incomplete. This also precludes the inclusion of diagram skill assessment in many of the university summative exams. Not all students are equally competent in deciphering the skill of drawing. In spite of too many differences in the innate ability of the students to draw the diagrams and too little formal training for the students in the drawing skills, anatomy summative assessments continue to revolve around drawing meaningful, simple yet effective diagrams. With the advent of newer print technology and imaging methods, medical illustrations in the textbooks are hardly reproducible on the paper.<sup>10</sup> These diagrams are good for overall understanding for the 3D structural relations. However, these illustrations definitely elicit initial interest, but fails to transform into long lasting retentive memory.<sup>11</sup>

Drawing diagrams is not limited to medical field. It is an essential skill among all students of science streams.<sup>12,13</sup> Researchers have tried to inculcate drawing skills through several ways. Muliani Joewono et al have shown that drawing diagrams improves the comprehension of musculoskeletal anatomy among medical students.<sup>14</sup>

There are attempts to compare drawing skills and dental skills among junior dental doctors.<sup>15</sup> Mark Backhouse et al, have advocated an artistic process comprising of observe-reflect - draw - edit - repeat (ORDER) technique to enhance the student learning. Such techniques involving continuous inputs shall bring about active learner engagement.<sup>16</sup> Stephen Reid et al, have experimented haptico-visual observatory drawing method, where five voluntary students using haptic senses coupled with drawing reported enhanced appreciation of the 3D structural orientation.<sup>17</sup> Sarah Greene has reported computerized screencasts of drawing based on the principles of progressive drawing has brought in improved diagram depiction.<sup>18</sup> Satish B Nayak et al, have tried progressive drawing technique to impart interest during the interactive lectures. This technique hovers around the concept of progressive revealing the anatomical structures on the blackboard and making the learners to predict and label the structures.<sup>19</sup>

With increasing use of PowerPoint presentations, use of black board for drawing diagrams is declining.<sup>4,8,20</sup> In this study, it will be attempted to improve diagram drawing skills using PowerPoint for moderately complex anatomy diagram.

## 2. Objectives of the Study

1. To evaluate sequence graphics to impart drawing skills among medical undergraduates.
2. To design and evaluate an objective method of assessment of clinically relevant moderately complex gross anatomy diagrams.

## 3. Methodology

### 3.1. Study design

Experimental study.

### 3.2. Study population

First year medical undergraduates.

### 3.3. Sample size

All 100 students from the regular batch were invited to participate in the study.

### 3.4. Inclusion criteria

Students who are willing to take part in this diagram-writing exercise.

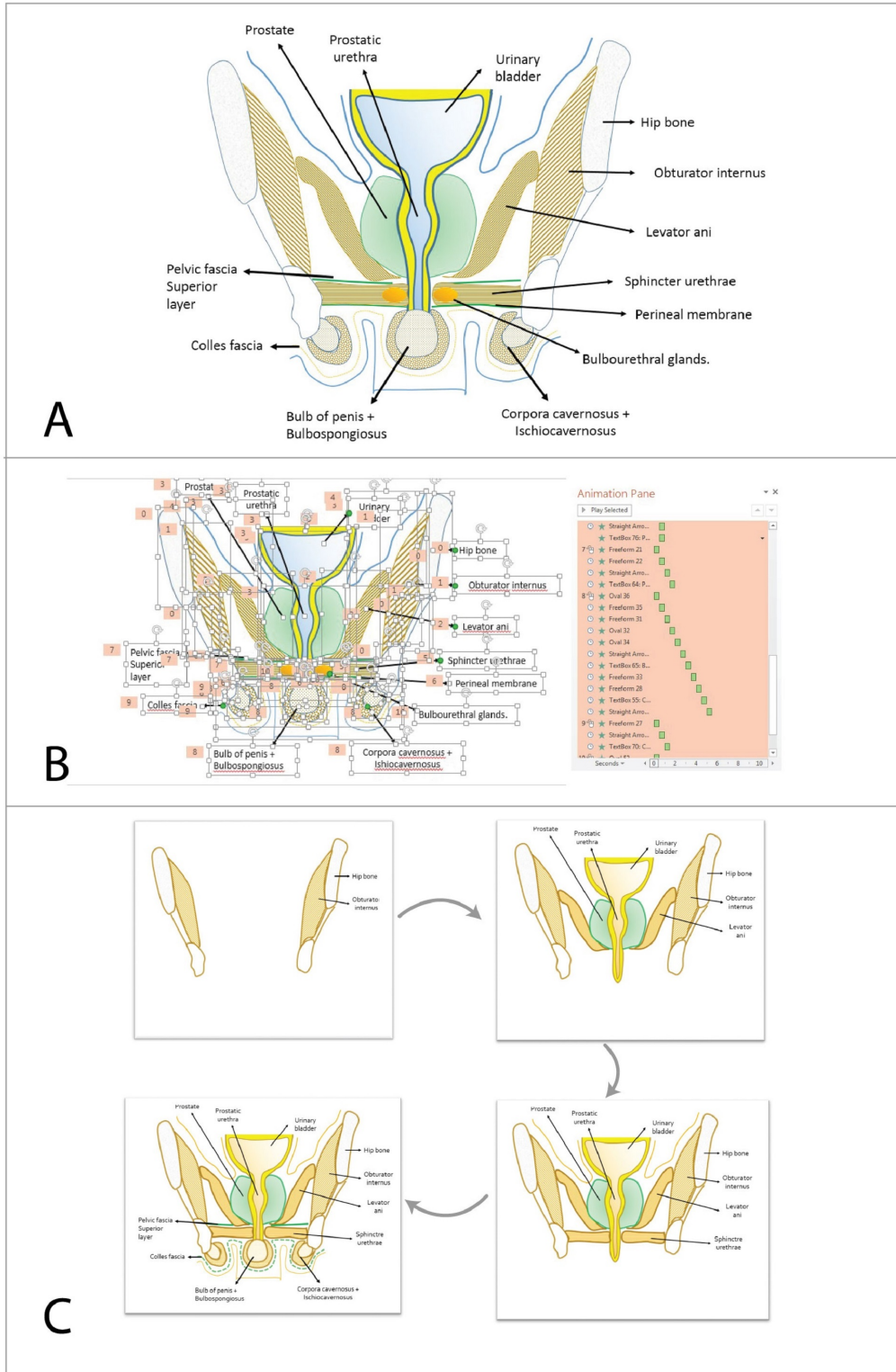
### 3.5. Exclusion criteria

Students who do not give consent to this teaching – learning method.

Institutional ethics committee approved (letter number AEC/Rev/2016/14 dated 30-11-2016) the proposal before starting the study.

### 3.6. Diagram selection and defining key components

Clinically relevant moderately complex diagram selected for the study was coronal section of the male pelvis. The selection of the diagram was based on consensus of the faculty in the department about the relatively difficult diagrams. As sequence graphics and objective evaluation of the diagrams was conducted without prior validated methods, much easier and too difficult diagrams were not considered. The prototype diagram was taken from the text book - clinical anatomy by regions by Richard S Snell.<sup>21</sup> The perineal membrane was the key component. Prostate gland (with urethra), deep transverse perineal muscle (with bulbourethral glands) and Colle's fascia were accessory components. The perineal membrane forms the division between the superficial and deep perineal spaces, also many important structures pierce this structure, was considered as key component. The students need to know the difference between position and drainage of bulbourethral glands in males and Bartholin's glands in females. (Figure 1)



**Fig. 1:** **A:** Clinically relevant moderately complex diagram selected for the study was coronal section of the male pelvis; **B:** Screenshot of the PowerPoint slide showing fifty three components of the sequence graphics used in the creation of the coronal section of male pelvis, made to appear sequentially on 10 clicks; **C:** Screenshots of the four on click events during the sequence graphics

### 3.7. Sequence graphics

Using the PowerPoint presentation program, various components were retraced and sequentially animated along with their labelling (Figure 1 A). During this process, the skeletal elements were made to appear first as they form the framework for the attachment of other structures. Muscles, connective tissue and neurovascular structures followed this.

### 3.8. Mode of preparation of the sequence graphics

In any presentation software, having the prototype image in the background, the components are drawn over it. Using 'curve' tool, retraces the outlines. Each component labelling follow immediately. All the components animated sequentially (Figure 1 B). Pre-defined key and accessory components receive more emphasis during labelling. However, all components appear in the predefined sequence.

On running the presentation, the components appear sequentially and provides a visual building of the complex diagrams (Figure 1 C). Sequence graphics follows many principles of progressive drawing. The line diagram concentrates on the ability of a novice learner to draw the same in minimum stipulated time. At the same time, the process of drawing along with sequence graphics coupled with explanation during the interactive lecture provides lasting impression of the diagrams. The video (Video 1) export of the same was shared with students.

### 3.9. Study design

All students were asked to draw the section of the male pelvis projected as static image on a standard A4 size paper in 10 minutes. Later students were asked to draw the diagram following the sequence graphics method as it appears on the screen on the back of the same page. Time of total sequence graphics was 7 minutes with sufficient time allowed after each component. Each component was made to reappear three times in order to provide orient the learner about where to start drawing and how to proceed.

Diagrams draws were collected and photographed. Images were stored electronically.

Both diagrams were analyzed for the parameters listed in table 1 and graded accordingly.

Though anatomy learning is perceived as dominated by diagram drawing, there are hardly any studies objectively evaluating the diagrams.

Sequence graphics method of drawing was pilot tested earlier to the present study with 12 student voluntaries. During the pilot study, centeredness of the diagram, use of eraser, sequence drawing, sequence labelling and average time taken to draw the diagrams were noted. It was found that, with sequence graphics technique, the diagrams were more centered drawn with sequential addition of the components and labelling. Use of eraser was significantly

less number of times and the diagrams were drawn in less time than with conventional method of image tracing.

A 5X5 grid digital adjustable transparent grid will be used to determine the centeredness and deviation. Drawing the accessory component more than one grid away from the key component was taken as deviation.

Mean scores of diagrams drawn first with the static image and with sequence graphics were noted and statistical difference was noted with paired student t test. Values less than 0.05 was taken as significant difference. A five-item student's feedback was obtained evaluating the immediate response of the students for the effectiveness of the sequence graphics.

## 4. Results

Out of 100 students, who have participated, diagrams of six students were not included as they have failed to write at least one diagram. Two other students were excluded as they have drawn the diagrams on a non-A4 size paper. Out of 92 students who participated by drawing both the diagrams, the mean scores of static image tracing and sequence graphics were 4.72 ( $\pm$  2.18) and 6.04 ( $\pm$  2.03) respectively. The difference was statistically significant ( $p < 0.001$ ).

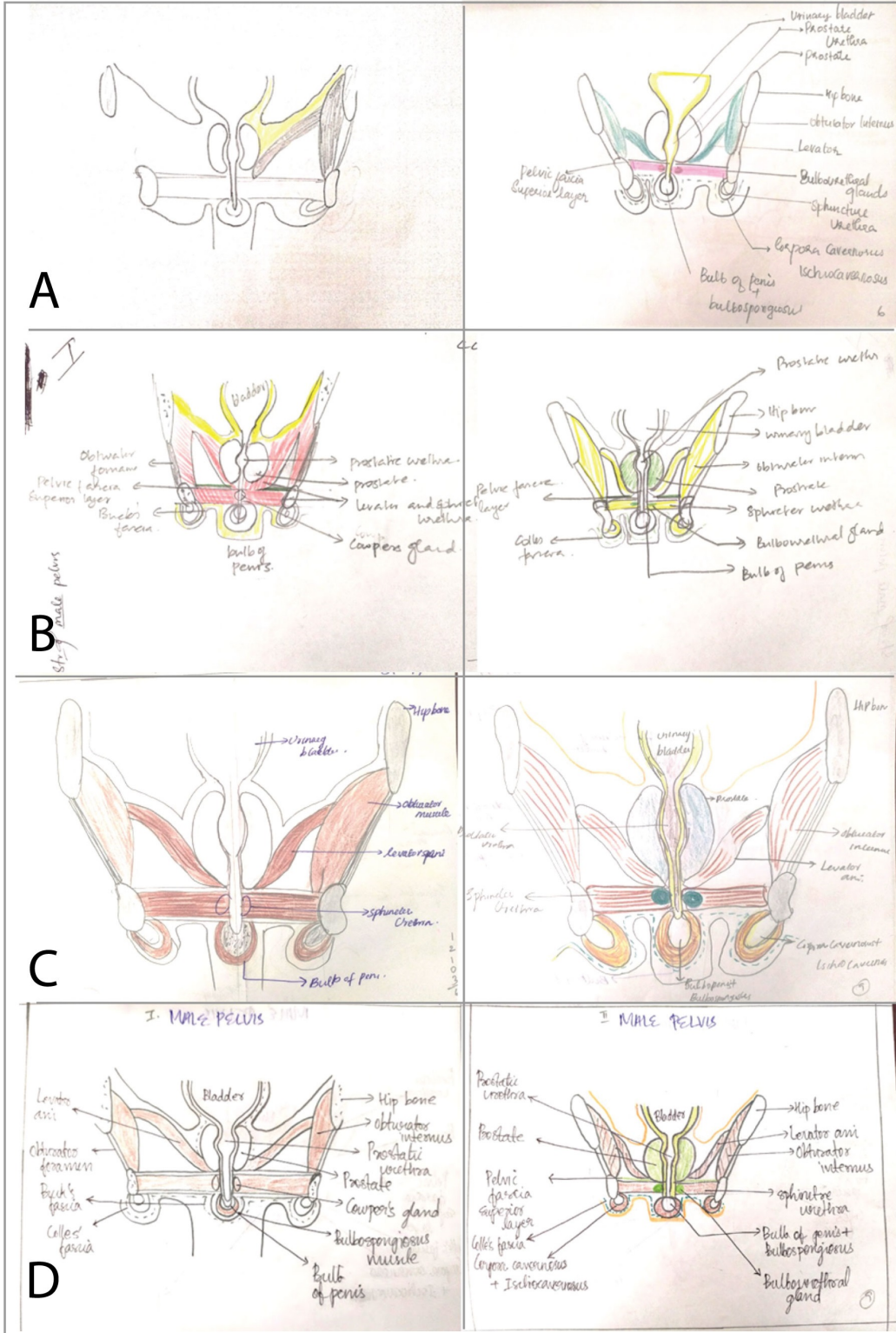
The improvement was particularly in terms of symmetry, representation of key and accessory components, labelling and use of appropriate colors (Figure 2 B). Sequence graphics resulted in drawings with predefined components with labelling. There was less of hesitancy and ease of progression (Figure 2 A).

Table 2 tabulates the five-item student feedback. Most students felt drawing diagrams with sequence graphics was easy. Students also expressed the key components of the diagram should be routinely revealed and emphasized during all classes.

## 5. Discussion

Drawing the key components in a moderately complex illustration along with a good concept delivery in an interactive lecture can elicit student thinking.<sup>14,22</sup> Strategies concentrating on the improved causal explanations, progressive transformation from known to unknown shall lead to effective cognition and more retention.<sup>23</sup> In a classroom setting, use of animations, 3D models to explain the complex spatial orientation of the anatomy structures brings in more clarity.<sup>24</sup> The learner need to represent these concepts at least schematically on a paper by drawing the concepts internalized. Quite often, students tend to copy the diagrams without sound scientific basis. Sequence graphics brings about the meaningful and retentive basis of drawing diagrams.

On the similar principles as that of sequence graphics, Satheesha Nayak et al have described a novel method of progressive drawing. They have used this drawing technique



**Fig. 2:** Diagrams drawn by four participants. Diagrams drawn with conventional method from tracing the static image (on the left panel) and with sequence diagram (left panel). Note the left panel diagrams are more centred, symmetrical, key and accessory components are represented.

**Table 1:** Parameters and scoring pattern for objective evaluation of the diagrams drawn

Parameter	Points (maximum 10)
Key component - perineal membrane	1
Accessory component	
Prostate gland (with urethra)	
Deep transverse perineal muscle (with bulbourethral glands)	1 point each
Colle's fascia	
Centeredness	1
Appropriate color usage - black for the bone, brown for the muscle, green for the fascia	Overall proper usage of colors - 1
Bilateral symmetry	1
Labelling	1
Deviation of all three accessory components	0
Deviation of one or two accessory components	1
No deviation of accessory components	2

**Table 2:** Tabulation of five-point student feedback regarding sequence graphics and key components taken immediately after drawing diagrams (n=92)

Difficulty level of static image to draw (1 very easy and 5 most difficult)	4.93 ( $\pm 0.24$ )
Difficulty level of sequence graphics to draw (1 very easy and 5 most difficult)	1.08 ( $\pm 0.28$ )
With Sequence graphics, I can start and proceed drawing diagrams confidently (1 strongly agree and 5 strongly disagree)	1.17 ( $\pm 0.38$ )
Key components of the diagrams should be revealed for every diagram (1 strongly agree and 5 strongly disagree)	1.31 ( $\pm 0.6$ )
Key components should be emphasized in every diagram (1 strongly agree and 5 strongly disagree)	1.22 ( $\pm 0.49$ )

either at the beginning of the class 'lid-opener' or during the middle of a lecture 'monotony-breaker'. In this method, the students contribute to the diagram by drawing one structure at a time in turns. This is an activity based interactive session. Students expressed that this method is an excellent way to recall.<sup>19</sup> In the same way, Carmichael and Pawlina have described a method of animated PowerPoint as a tool to teach anatomy. The scanned pen and ink images, manipulated with image processing program are used as teaching aid. These images undergo enhancement to delineate the key components. These images will be imported into the PowerPoint and undergo progressive animation. During the lecture, students sequentially labels the components on the lecture handout.<sup>25</sup> Such lecture handouts were not used in our scenario, as one of our objective was to impart diagram-drawing skills.

Recent medical curricula across the globe has undergone significant changes. Now, a medical student need to be competent in set of defined competencies.<sup>26</sup> Drawing diagrams is not the defined competency a medical student needs to achieve. However, both formative and summative written evaluation in anatomy still lingers fundamentally around the students' ability to draw the diagrams on the paper.<sup>27</sup> The student needs to draw a neat-labeled diagram in a stipulated time. The complaint of the students over the years is that they did not get enough time to draw the diagrams in the theory exams. In spite of all these efforts from the students' side, there are miniscule guidelines for objective evaluation of the diagrams. The diagrams

that follow the basic principles of anatomy illustrations including use of defined colors scores more. The evaluator appreciates the centrally placed, large, labelled, symmetrical and simple schematic diagrams better. Attempts to represent complex 3D pictures with shades and shadows often have dismal outcomes.

In the present study, we have attempted to define the criteria for objective evaluation of the diagrams. During the objective evaluation, key components of the diagram commands more weightage. Defining key components and accessory components in every diagram and communicating the same to the students, stressing on these components leads to unanimous representation in the written diagrams. Awareness of key components makes the students to draw them with more accurately. For example, in a transverse section at C6 vertebra, the fascial disposition over the thyroid gland and big vessels of the neck forms key components. In the brachial plexus diagram, the three cords with proper schematic representation of median, ulnar and radial nerves are the key components. In the transverse section at T4 level of thorax, the course of arch of aorta and superior vena cava are the key elements. In the anterior relations of the kidney diagram, the relation of pancreas and duodenum with the peritoneal relations are the key components. The representation of internal carotid artery branches and thin posterior communicating artery are the key elements in circle of Willis diagram. Consideration of the key components during evaluation brings more objectivity during evaluation. We recommend

key components be defined for all moderately difficult clinically relevant diagrams.

Sequence graphics is an engaging and cost effective method that can be easily implemented in every lecture class. There are no additional tools required to create the sequence graphics. With white board animations, sequential drawing is possible.<sup>28,29</sup> Use of Cascading Style Sheets (CSS) and Scalable Vector Graphics (SVG) animation coding shall bring about similar outcomes.<sup>30</sup> However, to do such animations, one needs to be good at coding. Sequence graphics is based on progressive drawing. During sequencing, the teacher is free to move in the classroom. So, monitoring of the students drawing becomes easy, which hitherto not possible while drawing the diagrams on the blackboard. The sequence graphics also goes away with the visibility and color contrast problems of blackboard drawing. We are successfully using sequence graphics in most of the routine interactive lectures. During these lectures, students get information about the key components of each diagram. The principles defined above for the objective evaluation of the diagram are followed during all our formative written assessments in anatomy.

## 6. Conclusion

Defining key component and accessory components for moderately difficult diagrams shall result in objective evaluation. Sequence graphics principles aids better drawing skills.

## 7. Source of Funding

Nil.

## 8. Conflict of Interest

Authors declare no conflict of interest

## 9. Notes on Contributors

S VIVEKA, MD, DNB (Anatomy) is a professor of Anatomy in Department of anatomy, at Azeezia Institute of Medical Sciences and Research, Kollam, Kerala, India. He teaches human anatomy to medical and dental undergraduates. His areas of interest are teaching and education research with content development for online learning.

M J SUDHA, MD, DNB (Pharmacology), MBA, is the professor of Pharmacology in Department of Pharmacology at Azeezia Institute of Medical Sciences and Research, Kollam, Kerala, India. She teaches pharmacology to medical and dental undergraduates. Her areas of interest are teaching, education research and ethics committee accreditation.

## 10. Acknowledgement

Authors thank the first year medical undergraduates who have participated in the study. Also, thank the graphic designers at healiosmed.com who assisted in preparing the sequence graphics for the not just this study but also many moderately difficult diagrams.

## 11. Additional Resources

1. PowerPoint slide used in the study (coronal section of male pelvis - <https://drive.google.com/open?id=18EAYZazeDzihbQIenJr6uo-ePo-fKLW>)
2. The video made from this PowerPoint - access it here - <https://www.youtube.com/watch?v=PKvjmxidw2s>
3. PowerPoint slide of the coronal section of female pelvis - <https://drive.google.com/open?id=14tMQeJESn5S8t1eje-OBf4X2MGhgUxTx>
4. The video of female pelvis coronal section <https://www.youtube.com/watch?v=rB21FjAow1Q>
5. Compilation of scores of diagram assessment and feedback <https://drive.google.com/open?id=1BEvr9wAo-Y5o1Y6j7kv6R9h19U18i4Na>

## References

1. Borrelli M, Leung B, Morgan M, Saxena S, Hunter A. Should drawing be incorporated into the teaching of anatomy? *J Contemp Med Educ.* 2018;6(2):34–40.
2. Alhamdani FY, Hatem HY. Drawings as learning aid for the human anatomy students' based evaluation. *J Oral Health Craniofac Sci.* 2017;2(4):90–5.
3. Singh V, Kharb P. A paradigm shift from teaching to learning gross anatomy: meta-analysis of implications for instructional methods. *J Anat Soc India.* 2013;62(1):84–9.
4. Shahdad S, Khan MA. Chalk & Board or Power Point Presentation - Students View towards Method of Teaching Anatomy. *J App Med Sci.* 2017;5(10E):4155–8.
5. Vasanth S, Elavarasi P, Akilandeswari V. Evaluation Of Impact Of Power Point Versus Chalkboard Based Lectures On Medical Student's Knowledge And Their Preferences. *Ind J App Res.* 2017;7(11):155–6.
6. Goshi RC. Power point or chalk and board - students view towards method of teaching anatomy. *Int J Anat Res.* 2017;5(1):3510–2.
7. Tadepalli KS, Ahmed MA, Paul GRR, Kumar INKB, Reddy CRL. Teaching aids and students preferences in anatomy lectures in state of Telangana. *Int J Anat Res.* 2020;8(1):7300–4.
8. Meo SA, Shahabuddin S, Masri AAA, Ahmed SM, Aqil M, Anwer MA, et al. Comparison of the impact of powerpoint and chalkboard in undergraduate medical teaching: an evidence based study. *J Coll Physicians Surg-Pak JCPSP.* 2013;23(1):47–50.
9. Quillin K, Thomas S. Drawing-to-Learn: A Framework for Using Drawings to Promote Model-Based Reasoning in Biology. *CBE—Life Sci Educ.* 2015;14(1):es2.
10. Leung B, Saxena S. Teaching students head and neck anatomy through the art of drawing. *PMFA J.* 2017;4(5):1–3.
11. Kumar D, Rajprasath R. Drawing skills in anatomy education and the millennial learner: A cognitive and metacognitive viewpoint. *Res Dev Med Educ.* 2019;8:58–60.
12. Silano AA. The drawing as a learning aid in science. *Sci Educ.* 1950;34(1):51–5.
13. Terada Y. The Science of Drawing and Memory [Internet]. Edutopia. 2019 [cited 2020 Apr 24]. Available from: <https://www.edutopia.org/article/science-drawing-and-memory>.

14. Joewono M, Karmaya INM, Wirata G, Yuliana, Widiyanti IGA, Wardana ING. Drawing method can improve musculoskeletal anatomy comprehension in medical faculty student. *Anat Cell Biol*. 2018;51(1):14–8.
15. Al-Johany S, AlShaafi M, Bin-Shuwaish M, Alshahrani F, Alazmah A, Aldhuwayhi S, et al. Correlation between Handwriting, Drawing Skills and Dental Skills of Junior Dental Students. *J Contemp Dent Pract*. 2011;12(5):327–32.
16. Backhouse M, Fitzpatrick M, Hutchinson J, Thandi CS, Keenan ID. Improvements in anatomy knowledge when utilizing a novel cyclical “Observe-Reflect-Draw-Edit-Repeat” learning process. *Anat Sci Educ*. 2017;10(1):7–22.
17. Reid S, Shapiro L, Louw G. How Haptics and Drawing Enhance the Learning of Anatomy. *Anat Sci Educ*. 2019;12(2):164–72.
18. Greene SJ. The use and effectiveness of interactive progressive drawing in anatomy education. *Anat Sci Educ*. 2018;11(5):445–60.
19. Nayak SB, Kodimajalu S. Progressive drawing: A novel “lid-opener” and “monotony-breaker”. *Anat Sci Educ*. 2010;3(6):326–9.
20. Garg A, Norman G, Spero L, Taylor I. Learning anatomy: do new computer models improve spatial understanding? *Med Teach*. 1999;21:519–22.
21. Snell RS. *Clinical Anatomy by Regions*. Lippincott Williams & Wilkins; 2011.
22. Noorafshan A, Hoseini L, Amini M, Dehghani MR, Kojuri J, Bazrafkan L. Simultaneous anatomical sketching as learning by doing method of teaching human anatomy. *J Educ Health Promot*. 2014;3:50. doi:10.4103/2277-9531.131940.
23. Desy J, Busche K, Cusano R, Veale P, Coderre S, McLaughlin K. How teachers can help learners build storage and retrieval strength. *Med Teach*. 2018;40(4):407–13.
24. Estai M, Bunt S. Best teaching practices in anatomy education: A critical review. *Ann Anat Anat Anz Off Organ Anat Ges*. 2016;208:151–7.
25. Carmichael SW, Pawlina W. Animated Power Point as a tool to teach anatomy. *Anat Rec*. 2000;261(2):83–8.
26. Mullan PB, Williams J, Malani PN, Riba M, Haig A, Perry J. Promoting medical students’ reflection on competencies to advance a global health equities curriculum. *BMC Med Educ*. 2014;14(1):91.
27. Sharma M, Bajaj JK, Kaur K, Arora R. Introduction of formative assessment: an essential component of CBME. *Int J Anat Res*. 2019;7(2):6859–64.
28. Sohn E, Choy YC. Sketch-n-Stretch: sketching animations using cutouts. *IEEE Comput Graph Appl*. 2010;32(3):59–69.
29. Akbaş O, Pektaş HM. The effects of using an interactive whiteboard on the academic achievement of university students. *Asia-Pac Forum Sci Learn Teach*. 2011;12(2):1–19.
30. Dengler P, Dahlström E, McCormack C, Hardy V. CSS Animations and Transitions on SVG Attributes [Internet]. 2011 [cited 2020 Apr 25]. Available from: <https://dev.w3.org/SVG/proposals/css-animation/animation-proposal.html>.

### Author biography

**S Viveka** Professor

**M J Sudha** Professor

**Cite this article:** Viveka S, Sudha MJ. ‘Sequence graphics’ for gross anatomy diagrams and their objective evaluation. *J Educ Technol Health Sci* 2020;7(2):58-65.