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# Drawing skills in anatomy education and the millennial learner: A cognitive and metacognitive viewpoint

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**Abstract**

Drawing can be a useful tool to elicit student thinking and is a widely-used method for communicating scientific ideas. The task of drawing requires students to identify and recall necessary pieces of information they assimilated over a period of time and construct a mental model. However, millennial generation learners, owing to their immersion in 3D technologies, lack interest in practicing and learning from diagrams. This impairs learning and retention of visually-oriented subjects. In this perspective, we reflect on the cognitive and metacognitive processes associated with drawing to emphasize the important role of drawing in present day anatomy education.

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## Drawing and anatomy: a relationship across centuries

The link between the art of drawing and anatomy education can be elucidated from the historical record, such as paintings. Subsequently, anatomy education involved *dual channels* which had complementary effects in reinforcing anatomical knowledge. Students dissected cadavers to 'feel' the structures and anatomists used "blackboard" drawings to depict those structures. Owing to a paucity of illustrations, students used to copy the diagrams sequentially, and, in the process, mentally envisaged the anatomical planes traversed by the structures. The task of drawing require students to identify and recall the necessary pieces of information they had assimilated over a period of time and then construct a '*mental model*'.[1] This mental model was translated into a manual task (drawing by hand), which was a constructed response that indirectly reflected the student's knowledge.[2] Existing curricula, at the present time, requires students to communicate their content understanding via theoretical and pictorial representations. Pictorial representations, particularly diagrams, are considered a valid and simple tool for assessing student knowledge and student ability to communicate scientific ideas. As an aid to swift assessment, examiners in classes with high enrolments often opt to assess answer sheets based upon the diagrams *per se*.

## Why have millennial generation students lost interest in drawing?

Students from the millennial generation – millennial learners – are accustomed to interactive and engaging learning materials from their childhood. With significant advances in software and technology, millennial learners have high standards and expectations of how content is presented. In addition, the need to cover a great deal of information in a classroom coupled with a lack of optimal logistics in classrooms as well as fear of being deemed 'out of date' requires faculty to adopt newer teaching-learning methodologies. On one hand, animation-based pedagogies, adopted by many faculty currently, help students understand some difficult concepts and expose them to 'realistic' models. On the other hand, the large

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amount of information offered in these pedagogies[3] can overload students, which hampers integration into an effective mental model. Furthermore, students have been observed to have difficulty in translating information received in 3D via animations and videos in classroom into diagrams, which are a 2D representation, that is, limited in spatiality.[4] This has resulted in gradual impairment in absorbing and reproducing visually-oriented subjects, such as anatomy. A study conducted among students in three different academic years concluded that the action of drawing in and of itself can improve musculoskeletal anatomy comprehension in students.[5]

## Cognitive principles pertaining to drawing skills

Mayer[6] postulated that *live* drawing enables a student to engage both in terms of the *psychomotor component* via usage of their hands to draw structures, but also the *cognitive component* by anticipating and constructing the next structure to be drawn (*self-explanation)*. We feel that the absence of this learner engagement in a dual sense may have resulted in the reduction of drawing abilities in millennial learners. Secondly, metacognitive abilities such as *self-monitoring*, which involves error detection, rectification of errors, and organization of knowledge[7], are honed by drawing, which leads to deep learning and an improvement in long term memory. In contrast to drawing, where temporal development of a complex structure takes place, multimedia learning offers a predetermined schema, thereby limiting opportunities for critical thinking by novice learners. The complexity behind learning drawing can be understood by analysing the interconnections of ideation and practice. Generative theory[8] postulates that drawing requires the internalisation of verbal text by assimilating the knowledge gained. Naug et al[9] postulated that drawing plays a crucial role in fostering metacognitive processes while students absorb new information sequentially and, owing to this fact, formative learning can be better assessed using drawings.[10,11]

Lyon et al[12] found that in collaborative drawing sessions, students gained confidence and interest in exploring the strengths and weakness of their partners' drawings. Metacognitive learning outcomes gained from collaborative practices include the honing of observation skills, continual critical analysis of what they see, and appreciation of differential approaches to the same task. After participating in various sessions, students were aware of learning shifts and could make use of learning gains of the module in other settings.

## How does a student learn to draw?

Anatomical drawing, in its broad spectrum, ranges from copying a schematic representation to sketching three-dimensional observations in a simpler way. For example, drawing the brachial plexus schematically and drawing histological images by observing under microscope are examples of the range anatomical drawing can encompass. The highest degree, which requires portrayal of an abstract scientific phenomenon, is not usually expected from undergraduate students.[13] But even the simpler forms require co-ordination and comprehension, which eventually enhance the motivation to learn.[13]

Juxtaposing the anatomy drawing skills with *Dave's psychomotor taxonomy*,[14] we can find that learning it travels in a trajectory: imitation, manipulation, precision, articulation, and naturalization. In the first step, the student visualises the image and copies it. Next, the student reads the instructions and attempts to perform certain actions. In due course, the learned actions become more refined and achieve higher levels of precision. We can deem a student to be competent in drawing when achieving this level. The last two levels, articulation, which involves combining of artistic skills resulting in a complex format, and naturalization, which involves the highest level of performance, are levels which can be expected from talented, artistically gifted students.

## Limitations for inculcating drawing skills in present day classrooms

While comparing a 'line by line' anatomical diagram with its corresponding 3-D image, it is essential to consider the impact of the *"imagination effect."* Constructing a mental image is a complex process which involves adding one part to another, often overlaying these parts, and can be aided by diagrams.[15] On the other hand, reviewing the mental image for comparison purposes (as in histology) involves activation of the entire image and this can be better provided through a multimedia image.[15] With the decrease in time available for the anatomy curriculum, as well as wide availability of high quality multimedia images, it is natural for students to opt for storing and reactivating the pre-formed whole image rather than a time-consuming diagram alternative. This can be presumably corroborated with the decrease in the ability to draw among millennial learners.

It should also be mentioned that the ability to draw should not be considered as a standalone parameter for evaluating the knowledge or intellect of a student, as subsets of students with altered learning style preferences might have difficulty in recreating diagrams. Borrelli et al[16] proposed anatomy drawing workshops as a model for teaching anatomy. The participants in those workshops perceived that lack of time and inadequate skill were the biggest constraints for drawing anatomy.

## Conclusion

In conclusion, drawing, which is slowly losing its exigency among millennial generation students, has its own credentials in fostering deep learning and long-term memory. Although a classroom of millennial learners is said to lack the patience to observe and assimilate *live* drawing-oriented teaching, attempts should be made to

**Box 1.** Salient Points

1. Drawing skills require students to identify and assimilate necessary pieces of information which students receive over time. This "mental model" helps to analyse a snapshot of student's perceived knowledge.
2. Millennial generation students have difficulty in translating 3D information via animation-based portrayals compared to 2D representations of diagrams.
3. Teachers should understand the cognitive and meta-cognitive underpinnings of drawing skills.
4. Students usually ascend the psychomotor ladder while learning drawing; however, only a subset of students reach the pinnacle.

help students realize the importance of drawing. In fact, diagrams, apart from being a mode for communicating learned content, can help students to transit different levels of abstraction, which is one of the ultimate aims of anatomy education (Box 1).

## Ethical approval

Not applicable.

## Competing interests

The authors declare that there is no conflict of interest.

## Authors' Contributions

DK has defined the concept, done literature search and designed the manuscript. RP has contributed towards manuscript preparation, edited and helped in terms of technical inputs.

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