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Using Theoretical Frameworks to Teach Anatomy

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Abstract

Active learning is incorporated in medical education at all levels and disciplines including Anatomy. Anatomy is recognized as a central core of health professions education and innovative approaches are reported in the literature to teach anatomy. However, many of these approaches do not describe the theoretical frameworks on which these approaches were based. In this article, we present the theoretical frameworks which may be considered by the faculty when designing learning experiences for the students. These theoretical frameworks set the foundation of active learning with clear aims behind the use of a particular innovative method. Each theoretical framework follows example(s) to make it easier to understand and apply in any setting.

Keywords

Medical Education, Innovation, Teaching and Learning

1. Introduction

Active learning is an educational approach to facilitate students' engagement with the learning process through the use of activities like regular reflection, self-evaluation, problems and cases, and/or projects to improve knowledge and skills (Luc & Antonoff, 2016; Machemer & Crawford, 2007). In higher education, students are encouraged to lead the learning process instead of being passive recipients (Felder & Brent, 2009). The demand for integration of active learning in university education systems is increasing nowadays and more so for health professions education. This has led to curricular changes and the introduction of strategies promoting active learning across all phases of medicine such as problem-based learning, case-based learning, flipped classrooms and team-based learning. Another paradigm shift that is observed in recent years is

the integration of subjects and disciplines rather than clear boundaries of the subjects taught.

Anatomy sets the foundation of medicine as a profession and there is a volume of knowledge to be retained and learned by medical students. Traditionally, Anatomy teaching involves, lectures, dissections and tutorials however this approach is not considered conducive to the learning despite being labor-intensive as the focus is on surface learning approaches and rote memorization (Singh, Bharatha, Sa, Adams, & Majumder, 2019). This has led educators to adopt teaching approaches which can simplify complex concepts so learners can apply the concepts in clinical environments. This implies that the anatomy curriculum is revised to make it more relevant to what is needed in the current environment. The focus has shifted from rote memory to application of the knowledge and concepts integrated with other disciplines like physiology and biochemistry. This paradigm shift has placed pressure on anatomy educators to ensure that medical graduates possess the required knowledge and are safe practitioners in a limited time. Hence the teaching strategies have shifted from traditional descriptive anatomy to clinical orientated anatomy, which urges the faculty to adapt with the situation and try newer teaching approaches. Simultaneously, there is a push to incorporate active learning in undergraduate medical education, despite traditional didactic lectures still being a standard for content delivery for many medical schools (Mc Keown, Heylings, Stevenson, Mc Kelvey, Nixon, & McCluskey, 2003).

The educators have responded to this challenge with the introduction of inspiring and motivating activities to facilitate learning as reported in the literature. However, it is observed that the description of the activities does not include the theoretical frameworks on which these activities are based. This may be perhaps because of the lack of knowledge in terms of pedagogical concepts or that the journals do not require the authors to report the frameworks.

In this article, we present example(s) against the six broad theoretical frameworks (**Table 1**) used in another literature review related to mobile learning (Naismith, Lonsdale, Vavoula & Sharples, 2004).

Table 1. Theoretical frameworks.

	Framework	*Activities*
1	Behaviorist	Activities promoting learning as a change in learners' observable actions.
2	Constructivist	Activities encouraging learners to construct new ideas or concepts based on their previous and existing knowledge.
3	Situated	Activities that provide an authentic context and culture to promote learning.
4	Collaborative	Activities promoting learning through social interaction.

Continued

5	Informal and lifelong	Activities that support learning outside a dedicated learning environment and formal curriculum.
6	Learning and teaching support	Activities that assist in the coordination of learners and resources for learning activities.

Each theoretical framework is explained with relevant example(s) from the educational approaches used in Anatomy. This will enable the readers to apply the various active learning strategies as per their needs.

2. Theoretical Frameworks

2.1. Behaviorist Framework

The basis of this framework is "assessment through teaching" (Huitt, Killins, & Brooks, 2015), and behavioral changes are acquired through linking stimuli and response. Within this framework, faculty defines a set of the learning outcomes and the student needs to achieve those learning outcomes to progress depending on the assessment criteria.

Let us observe an example. With the learning objective: "Demonstrate the origin, course and major branches of the common, internal and external carotid arteries and location of the carotid pulse," the faculty instructs students regarding each part of the learning objective's content. The assessment that follows comprises questions regarding the learning objectives and can be in the form of multiple-choice questions, short-answer questions, or matching/filling the gap or labeling the diagram. Depending on the criteria to pass the test, a student may pass or fail.

2.2. Constructivist Framework

According to the cognitive-learning theory, this approach allows learners to construct new knowledge upon the previous learning experiences rather than receiving new information directly. This implies that the educational worth comprises of both the student's learning experience and the perception of those experiences (Boghossian, 2006).

Problem based learning is one of the best examples to demonstrate constructivist framework. Initially started with paper-based cases, the advent of technology has allowed faculty to use various modalities. For example, instead of a lecture on the skeleton of upper limb, one can use a video clip from one of the sporting events such as cricket, basketball etc. and let students discuss what muscles are involved in the actions and what will be the effect if one gets injured. It also allows to integrate learning across different disciplines like physiology for example in the same case facilitator can probe student understanding of inflammation and effect of injury on muscles.

Mota et al. incorporated constructivist pedagogy when teaching digestive system in small groups (Mota, da Mata, & Aversi-Ferreira, 2010). The anatomical parts of the digestive system were distributed across five tables in the laboratory.

Each group chose a table and received the guide, containing the structures to be studied, as well as a textbook and an atlas of Anatomy. The groups identify the structures, followed by studying and locating the information regarding the structures, and asking questions. After finishing tasks at one table, the group moves to next table and by the end of the session, the content of the digestive system was covered.

2.3. Situated Learning

Situated Learning is more about learning outside traditional classroom settings where the focus is on the relationship between learning and the social situation in which it occurs (Cobb & Bowers, 1999).

Using art-related activities to establish anatomical relationships is not uncommon among institutions. Platt et al. introduced an anatomy portfolio in the class where students use creative media including poetry and abstract art to demonstrate their understanding with a written reflection (Platt, Salmerón, & Hatcher, 2021).

Recently 3D printing models are also used to teach anatomy. 3D printed models allow students to explore intricate anatomical structures in tangible form, enabling a hands-on approach for spatial understanding as demonstrated by Cai B and team who used 3D printer to create a functional knee joint and observed a positive effect on student learning (Cai, Rajendran, Bay, Lee, & Yen, 2019).

2.4. Collaborative Learning

"Collaboration" refers to the more humanistic relations in the classroom encouraging learners to become more active, autonomous, and self-responsible (Whipple, 1987). Collaborative learning includes activities which promote social interaction between the students. Paul G. McMenamin used body painting to teach clinical application of anatomy (McMenamin, 2008). Later, other educators have also tried to integrate the use of body painting in anatomy classes. More recently, Shapiro with his team reported Haptic surface painting to develop spatial awareness (Shapiro, Hobbs, & Keenan, 2023).

The COVID-19 pandemic affected the delivery of the curriculum at all levels, and this was the prime time when most of the innovative teaching methods were incorporated. In 2021, Border et al. used a participatory approach to integrate blended teaching, learning and scholarship strategies. The faculty joined hands together with the students and asked them to create resources to support each other. The students and faculty were engaged in all steps of collaboration, code signing the curriculum and learning resources, which reduces barriers in instruction and supported student learning (Border, Woodward, Kurn et al., 2021).

2.5. Informal and Lifelong Learning

Informal learning refers to embedded learning activities that are linked to per-

formance, in the setting of one's everyday life (Beyer, Delgado, Davis, & Krajcik, 2009). In addition, learners have the autonomy to decide the time for study and the method that best aligns with their demand. This helps students with diverse learning styles. Virtual applications are also a great source to encourage students to learn at their own pace.

2.6. Teaching and Learning Support

Learning resources play a fundamental role in the success of any learner. These resources typically contain content and skills for students to learn, provide activities for teaching these ideas, and specify pedagogical methods.

The traditional way of teaching anatomy—dissection of cadavers, demands skills not only from the faculty but also from the students, in addition to availability of cadavers. The provision of advanced materials has revolutionized the field of teaching and learning anatomy, providing unparalleled support, and enhancing the overall educational experience. Numerous technologies and resources such as computer-based learning, medical imaging, virtual anatomical models, and other digital technologies are now available for teaching anatomy knowledge in lieu of traditional dissection methods (Khalil, Abdel Meguid, & Elkhider, 2018). These include interactive anatomy tables, and anatomy applications playing a key role in visualization of human body's structures.

Virtual Reality (VR) simulations provide a dynamic environment where learners can dissect virtual cadavers and explore anatomical systems with a level of detail and realism previously unattainable. The haptic feedback technology is capable of allowing students to visualize and interact with the virtual specimens with accurate insight of the structures in various states (Johnson, Charchanti, & Troupis, 2012). These materials not only make anatomy education more accessible and inclusive but also empower students to grasp complex anatomical concepts effectively in their own time, thus shaping the next generation of healthcare professionals. Howell et al. developed the Virtual Haptic Back to simulate mechanical properties of the human back for first year medical students to practice their manual skills (Howell, Conatser, Williams, Burns, & Eland, 2008). The feedback from students supports the use of simulator as an effective tool for engaging students.

3. Multimodal Activities

At times learning activities cannot be restricted to one teaching framework and faculty may adapt blended learning, which incorporate multiple models in teaching to promote better interaction. One such example was reported in 2014 where virtual microscopy was an additional introduction in the histology laboratory (Gatumu, MacMillan, Langton, Headley, & Harris, 2014). Students in teams used both virtual and traditional light microscopy. The faculty facilitated learning among students to select, explore and annotate Virtual Microscopy images as seen on individual desktop computer screens. A printed handbook

guided the students through the slides with lecture demonstrations in the same class.

Team based Learning is another approach which incorporates multiple frameworks. The first phase comprises preparation for the session through the provision of resources (Teaching Learning support framework). The second phase introduces individual readiness assurance test (iRAT) which is a form of behaviorist framework, while the team readiness assurance test (tRAT) uses the collaborative framework. During the preparation for the tests, students use a variety of resources that support teaching and learning, and afterward, they can refer to the sessions for revision (lifelong learning).

4. Discussion

The application of well-designed educational frameworks in medical education is crucial for fostering effective learning environments, to help student in achieving learning objectives and, in long-term, prepares students for the challenges as a professional. The discipline of anatomy is not behind when comes to teaching innovation and curricular developments. However, several factors need to be considered when planning the strategies.

Active learning requires resources, both physical and human, so institutional support is vital for educators. For example, mobile devices are becoming a necessity. Singh et al. surveyed use of medical apps on smart phone and phone usage for education related tasks among medical students (Singh, Sarkar, Gaur et al., 2021). Despite reporting drawbacks, such as superficial information, unreliable databases, potential risks of causing health-related issues, a majority of students used smartphones for information, communication, time management and accessing medical databases. Yet, it should not be assumed that every student will have a mobile device so if faculty is planning to introduce activities which require mobile devices, the institution should be able to provide the device if required with necessary infrastructure.

When incorporating active learning approaches, the class/group size is also important and will determine the human resources required. The time for preparation for the sessions irrespective of theoretical framework is longer than what a faculty member will normally spend on preparing for a lecture. This needs to be taken into consideration when estimating the workload of faculty.

From the learners' perspective it is also important to consider the characteristics of the learners. Learning styles and study approaches determine how learners learn and engage with the process of learning so it is worthwhile to use multimodal approaches but be consistent and do not experiment with all frameworks in one course. It is important to understand one's teaching style and what frameworks will be feasible for the content being taught.

Assessment drives learning and the assessment tools need to be aligned with the approach used. Another area to be considered is that the sole purpose behind active learning approaches is to help students to learn and apply the learning in

clinical context. Therefore, it is important to observe the student performance. Huitt et al. studied TBL sessions as replacement for traditional dissection laboratory. The results review better performance from experimental group with TBL sessions as well as potential of improving long-term retention of knowledge, along with other non-academic benefits (Huitt, Killins, & Brooks, 2015).

Most of the evaluation studies only employ level one and two of the Kirkpatrick models but it is important that longitudinal studies are planned to compare cohort performances (Kirkpatrick, 1994).

5. Conclusion

In this article, the authors have provided a snapshot of how different theoretical frameworks can be adapted to incorporate active learning experiences with examples to assist the faculty. Though focused on Anatomy, these frameworks can be applied to any discipline. The understanding of these frameworks provides faculty with a sound knowledge and vocabulary to apply innovative methods. In terms of teaching anatomy, which has been referred to as the entrance discipline of medicine, these teaching frameworks will help students and faculty with variety of approaches to the knowledge, and to build firm knowledge base for the future health workforce through meaningful learning experience.

The authors have incorporated six broadly used theoretical frameworks but there may be more frameworks based on other prescribed domains. This may be a limitation of this article. It is though important that when an innovation or teaching strategy is reported the contributors mention the theoretical framework used. One other limitation is that the year 2023 has seen the emergence of ChatGPT-4 which is revolutionizing all fields including education of health professionals and is an area to be investigated further in terms of educational framework and its effective use. Currently, there is consensus that ChatGPT-4 is a valuable interactive tool that offers engagement of learners with ability to ask questions but it cannot replace educators and further research will inform the practice for its future use.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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