BRIEF COMMUNICATION

Balancing Information Load and Cognitive Load in Anatomy Education

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Anatomy, being a complex subject with vast content and interdependent components, requires effective teaching approaches to facilitate the successful integration of information into memory. Memory, consisting of sensory memory, working memory, and long-term memory, plays a crucial role in the learning process (1). Sensory memory briefly stores unlimited inputs from sensory organs, which, if actively attended to, are transferred to working memory. However, working memory has limited processing and storage capacity (approximately 20 seconds), necessitating the organization of information into manageable chunks known as schemas. These schemas are then encoded into long-term memory, which forms the basis of knowledge (2).

This article explores the concept of cognitive load theory, which aims to optimize teaching design by minimizing the cognitive demands on working memory, thereby promoting schema construction and integration into long-term memory.

Cognitive load theory focuses on designing teaching methods that prevent the overloading of working memory with excessive information (3). By reducing cognitive demands, this approach facilitates the creation of new schemas and their integration into long-term memory. The theory is based on five key principles that guide instructional design (4):

- Principle #1: Long-term memory changes enable learning: Effective learning occurs when there are changes in long-term memory. Therefore, instructional strategies should aim to modify and expand students' existing knowledge (5).

- Principle #2: Leveraging existing knowledge: Utilizing knowledge acquired from teachers and peers, rather than relying solely on self-discovery, makes the process of reorganizing and integrating information more accessible and efficient (6).

- Principle #3: Integrating fundamental information first: To ensure a strong foundation for learning, it is crucial to integrate fundamental information into long-term memory before introducing new concepts or details (7).

- Principle #4: Incremental alteration of long-term memory: Alterations to long-term memory should be introduced gradually and incrementally to avoid disrupting previously constructed knowledge. This gradual approach allows for the seamless incorporation of new information (8).

- Principle #5: Utilizing long-term memory resources: When information is processed from long-term memory, working memory has virtually unlimited capacity. Thus, leveraging pre-existing knowledge in long-term memory can enhance the integration of new information (9).

In essence, this model emphasizes the importance of not overloading information until it is integrated into long-term memory and utilizing pre-learned information that is already encoded in long-term memory as a resource to build new memories. The leading universities have successfully incorporated cognitive load theory into their curriculum design. In the next half of this article, I am proposing the following changes to the anatomy teaching curriculum in Sri Lanka based on my experience participating in teaching anatomy in such universities.

1. Reduce didactic lecture-based teaching:

   - Didactic lecture-based teaching, while crucial for delivering organized (principle#2) and fundamental (principle #3) information, is known to saturate working memory quickly.

   - Leading universities have limited the number of lectures and shifted to online platforms, allowing students to listen at their own pace, take notes, and research difficult concepts, thus avoiding working memory saturation.

   - One face-to-face Q&A session per week can be incorporated to facilitate interaction and clarification.

2. Vertical integration between subjects:

   - Introduce clinical skills into the basic sciences stream to help students identify the end goals of learning anatomy and make it more engaging.

- Rotate clinicians and basic scientists in teaching, allowing students to retrieve knowledge from long-term memory to working memory, promoting integration (principle #5).

3. Introduce reverse learning approaches:

- Implement problem-based learning or case-based learning, where students work backwards from clinical signs/symptoms to learn relevant anatomy.

- Encourage the use of freely available resources such as the "Visible Human Project" and "Radiopaedia" to access 3D reconstructions and serial sections for understanding anatomical structures and their relationships.

- This approach avoids abrupt shifts when transitioning from basic science to clinical streams (principle #4) and stimulates cognitive challenge, making learning more intriguing.

4. Incorporate active and self-directed learning:

- Assign student groups to analyse clinical cases and present the anatomical basis, requiring them to research and explore key anatomical concepts. These presentations help consolidate newly learned knowledge.

- Develop Kahoot quizzes based on student-generated multiple-choice questions, encouraging different perspectives and enhancing self-assessment skills.

- Utilize gamification techniques, such as memory games and celebrity heads, to make learning fun and facilitate the effective integration of working memory into long-term memory. This also promotes self-directed learning.

5. Assess higher-order outcomes beyond recall:

- Utilize viva assessments to evaluate students' organizational skills such as describing how structures in specific anatomical regions are organized into compartments.

- Include clinical skills assessments to evaluate how students apply anatomical knowledge in clinical scenarios, such as localizing lesions based on patient presentations.

In conclusion, optimizing anatomy education involves balancing the information load and cognitive load placed on students. The principles of cognitive load theory emphasize the importance of avoiding information overload until it is integrated into long-term memory and utilizing pre-existing knowledge as a resource for constructing new memories. By implementing effective teaching strategies, such as leveraging prior knowledge, promoting active engagement, introducing reverse-learning approaches and integrating clinical learning at an early stage of medical education, educators can create an environment

conducive to effective learning and long-term retention of anatomical knowledge.

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