

# Applying constructive alignment and cognitive load in teaching

Case study involving a foundational family medicine medical school course

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**F**undamentals of Family Medicine is a foundational course offered during the first term of medical school at Queen's University in Kingston, Ont. It introduces family medicine at an early stage and provides a broad introduction to the field of primary care. The course is well received by students, and graduates use the schema knowledge learned in this course as a basis for their clinical reasoning in clerkship and residency. An understanding of the teaching methods used in the development of this course can help clinical preceptors structure their teaching.

The 2 main obstacles to course development were that not all students are a priori interested in primary care, and that the sheer volume of knowledge that needed to be transmitted to an essentially lay audience was overwhelming. Our solutions lay in the principle of constructive alignment and the theory of cognitive load. Community preceptors can benefit from an understanding of these 2 teaching fundamentals when implementing new ideas in their clinical teaching practices.

Constructive alignment is a design for teaching in which learning goals and how students should express their learning are clearly stated before teaching modules are designed; teaching and assessment are then developed with those goals in mind. The process moves from learning knowledge for knowledge's sake to, first, figuring out what knowledge is needed to perform a real-world task well and, second, creating a learning structure that enables a learner to be able to perform the task during and at the end of the learning sequence.<sup>1</sup>

Cognitive load theory posits that to encode knowledge into long-term memory, working memory must interact with outside-world stimuli, select the relevant pieces of information, and process them in a way that enables the long-term memory to create a schema or map of relations among concepts.<sup>2,3</sup> This theory describes a model of our working memory as an apparatus containing a "phonological loop" that can hold short clips of audio information, and a "visuospatial sketchpad" that can contain visual information. Another component, an "episodic buffer," integrates various sources of stimuli into an integrated "event."<sup>4</sup> Working memory is limited in the amount of information it can store (7 items, plus or minus 2) and how many items can interact within it (4 items at a time).<sup>5</sup> Cognitive overload occurs when the working memory limits are exceeded, which is very detrimental to learning.<sup>6</sup> In addition, repeated exposure of short-term

memory to similar stimuli is needed to reliably transfer the information into long-term memory.<sup>7</sup> The fundamental problem in most teaching environments is not taking these facts into account, leading to overload of working memory. Good instructional design is paramount in creating useful learning environments. Understanding this theory can help clinical preceptors (and classroom instructors) design better approaches to teaching.

## Using constructive alignment to create student engagement

Family medicine encompasses topics that are relevant to all medical professionals, such as fever, cough, various types of pain (chest, abdominal, back, headaches), depression, and prevention. We structured the course around 16 such broad topics. Within each topic, we used constructive alignment to create a clear structure of learning goals that were relevant to the real-world practice of any clinician, provided a sequence of learning that supported these goals, and included an assessment that was fully aligned to the learning. This structure allows us to confirm that our students understand the concepts and are able to apply the material in meaningful, real-world contexts. It also avoided disengagement from students not intrinsically interested in family medicine.

## Using cognitive load theory to moderate cognitive load and enhance learning

*The way we structure ... information and think with it [changes our conceptions of the world]. Thus, education is about conceptual change, not just the acquisition of information.<sup>2</sup>*

We created a foundational schema for each clinical problem by first dissecting our own approach. We then divided the schema into discrete elements, each no bigger than the working memory limit. We presented the information in a multimodal fashion requiring engagement of both the phonological loop and the visuospatial sketchpad components. We limited the overall content to a minimal amount of information that could support the foundational schema without assumed prior knowledge. We used the flipped-classroom approach and required learners to engage with and learn the material at their own pace at home before each session. During sessions, we created an elaboration sequence,<sup>8</sup> first reviewing

individual elements of a schema before moving to complete schema presentation, and then elaborating on the complexities that can arise in a topic, using clinical cases of escalating difficulty. We also created a schedule of spaced reinforcement to ensure long-term memory retention. Once the basics were in hand, we gave the students a comprehensive e-book to deepen their knowledge. The following provides an example of this process.

### Example

*Topic:* Fever. A common clinical scenario encountered across all specialties.

*Learning goals:* Key real-life learning goals were selected through an iterative discussion among the course directors. We settled on these 7 goals for students:

- be able to define fever using various measurement methods,
- understand the sources of variability in fever measurement,
- understand the thermostat concept and the mechanism of heat loss and gain,
- separate fever from hyperthermia,
- know that hyperthermia requires cooling,
- know when to “dig deeper” in fever, and
- know how to treat fever for symptomatic relief.

This list was organized into a visual schema that was provided before class with an explanation using narrated slides (Figure 1). Presenting information in an audiovisual way engages the multimodal representation effects and has been shown to enhance learning<sup>5</sup>; schema-based learning has been shown to both reduce cognitive load and enhance diagnostic accuracy in medical learners,<sup>9,10</sup> presumably because it presents information in a way that is readily recognizable to the long-term memory systems that intrinsically use similar representations.<sup>3</sup>

Each slide of the class preparatory material contained narration that elaborated on no more than 7 points of information to stay within the limits of one’s episodic buffer. Whenever possible, information was presented visually. Students were given a week to go over the material at their own pace to manage their own cognitive load. All precourse material contained only limited content, each tied to 1 of the stated learning goals. Key points were clearly emphasized within each slide (Figure 2).

Students arrived at class prepared. In class, to create spaced repetition, we asked students to write out, from memory, the relevant information from the preparatory materials and draw the schema. We then engaged in simple activities like “Fever—Yes or No” based on the given temperature and the measurement method, or “Which method to use?” given a certain patient age (eg, rectal for confirmatory testing in age <2 years old). We then created an elaboration sequence of cases for discussion (Figure 3).

We built on this further with a spaced-repetition ladder. First, students were given a quiz with 4 questions

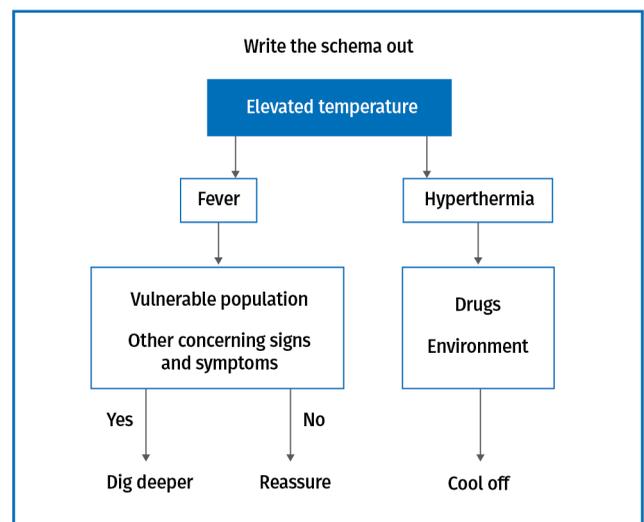
relating to the content within a week of each session. At the start of the next session, the essential points and the schema of the previous session were reviewed. The required preparatory slides from each class were reviewed prior to each summative examination (made possible by the limited amount of content), and each question on the quiz specifically aligned to 1 of the stated learning goals. Finally, the e-book with more in-depth material on each topic allowed students to broaden and deepen their knowledge on their own time within the context of our broader spiral curriculum.

### Results

Foundations of Family Medicine is an extremely well-received course. It has won lectureship awards in 5 out of the past 6 years. In a typical evaluation for the course, 95% or more of the students strongly agree that it was an excellent course that included clearly stated objectives and in which they learned a lot (n=367).

Some of the qualitative remarks supporting the use of the above-noted strategies are summarized in Box 1.

**Figure 1. Visual schema of fever**



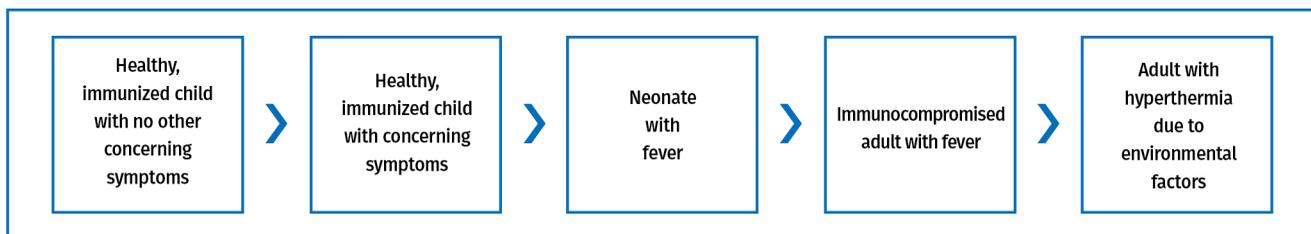
**Figure 2. Example of one slide in class precourse material**

Should fever be treated?

- Fever is uncomfortable
- It can cause febrile seizures in children
- It can stress a fragile cardiovascular system

In a healthy person, fevers are uncomfortable but harmless

Figure 3. Example of sequence of cases



### Box 1. Sample comments from course participants

- “I feel confident and ready to use what I learned [in] real-life situations.”
- “The prep materials were great; they covered all of the key concepts but weren’t overwhelming. The profs did a great job by encouraging the use of spaced recall; I didn’t have to study as much for this exam because I remembered content from the lectures much better than other courses.”
- “Lectures and pre-class material were extremely organized, and it was so helpful to have clear learning objectives. The review sessions were extremely helpful prior to the midterm and exam. The tests and assignments were fair and based on practical concepts. It was helpful to work through questions based on clinical cases.”
- “I really liked how the professors took complicated topics and made them into schemas we could understand.”
- “This course is proof that medical education at Queen’s can be done well. Other instructors should model their courses after this one.”
- “I always felt like I knew what was important and relevant, and the exams reflected what was emphasized the most. By far the best course we have had so far.”

## Conclusion

Constructive alignment and cognitive load theory are relevant to medical education and their thoughtful application can result in excellent learner experience. Setting goals and objectives based on real-life needs; respecting the limits of working memory; and facilitating information transfer to long-term memory via use of schemas, spaced learning, and elaboration are key facets of successful teaching based on constructive alignment and cognitive load theory. 🌿

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#### Competing interests

None declared

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## Teaching tips

- ▶ Structure knowledge into visual schemas.
- ▶ Use both audio and visual presentation of material.
- ▶ Limit the overall content and divide it to fit working memory.
- ▶ Tie knowledge to real-life use.
- ▶ Use an elaboration sequence.
- ▶ Create a spaced-repetition ladder.

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