Learning by concordance (LbC) to develop professional reasoning skills

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Abstract

Developing effective clinical reasoning is central to health professions education. Learning by concordance (LbC) is an on-line educational strategy that makes learners practice reasoning competency in case-based clinical situations. The questions asked are similar to those professionals ask themselves in their practice and participant answers are compared to those of a reference panel. When participants answer the questions, they receive an automated feedback that is two-fold as they see (1) how the panelists respond and (2) justifications each panelist gives for their answer. This provides rich contextual knowledge about the situation, supplemented by a synthesis summarizing crucial points.

As many educators in the health sciences are engaging in introducing innovative approaches, many consider building LbC learning modules. Elaborating, designing and implementing a LbC tool remain a challenge. This AMEE Guide describes the steps and elements to be considered when designing a LbC tool, drawing on examples from distinct health professions: medicine, nursing, physiotherapy, and dentistry.

Specifically, the following elements will be discussed: 1) LbC theoretical underpinnings; 2) principles of LbC questioning; 3) goals of the concordance-based activity; 4) nature of reasoning tasks; 5) content / levels of complexity; 6) reference panel; 7) feedback / synthesis messages; 8) on-line learning platforms.

Key words: Learning by concordance, Assessing by concordance, Reasoning, Professional education, Script theory, Tool design, Education in health sciences

Practice Points

- Script concordance testing (SCT) and Learning by concordance (LbC) are valuable modalities to help learners reason in context of complexity and uncertainty.

- The nature of the reasoning task can involve diagnosis, investigation, choice of treatment options, ethical considerations, and professionalism issues.

- It is important to expose learners to variability, in other words, to the absence of a single correct answer when reasoning in contexts of complexity and uncertainty, so characteristic of professional practice.

- The LbC concept can be used across the continuum of education from 1st year students to practicing professionals in continuing development.

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General overview

Terminology /definition

Concordance as an educational strategy has two branches.

- The Script Concordance Testing (SCT) branch concerns assessment. Described initially in the early 2000, it is the object of a vast literature including an AMEE guide (Lubarsky et al. 2013).

- The Learning by Concordance (LbC) branch, which is a more recent concept (Foucault et al. 2015; Fernandez et al. 2016; Lecours et al. 2018). It is the object of this AMEE Guide.

Importance of the topic

- Preparing professionals in any field implies preparing trainees to embrace complexity and uncertainty.

- LbC requires a shift of mind when elaborating the learning material. Instead of the usual sequence of knowledge uptake followed by application exercise, developers have to identify the key elements of reasoning in the domain; think of situations that induce reasoning on these issues; then generate the combination of hypothesis–new data that will make participants and panelists reason on these key elements.

- The nature of reasoning task can be very diverse. It can belong to diagnostic, investigation, choice of treatment options or else considering ethical or professionalism dimensions. Wording of the question varies accordingly.

- In LbC, the panel plays a fundamental role as each participant wonders "who are the individuals who pretend giving me feedback on my way of reasoning". To create a reference panel, three questions must be addressed: Who? How many? How to recruit them?

- Panel members vary in their interpretations. It is important to expose learners to this variability, in other words, to the absence of a single correct answer when reasoning in contexts of complexity and uncertainty, so characteristic of professional practice.

- Because panelists are asked to apply their reasoning skills in situations that are common in their clinical practice, it is generally easier to recruit them as compared to asking them to sit on traditional assessment panels.

The LbC concept has been described for the health professions but it can be used in any domain that requires reasoning in context of complexity and uncertainty and

across the continuum of education from 1st year students to practicing professionals in continuing development.

Aim/objectives of the Guide

The guide aims to introduce the readers to the various ways the LbC concept has been used to create an array of educational tools and to illustrate the basic steps or factors to consider when developing such tools.

At the end of the guide, readers will be able to

- Describe the theoretical underpinning of LbC
- Explain how questioning and concordance are realized
- Adjust the format according to the goal: assessment or learning
- Specify the nature of the reasoning task
- Adapt to the content and level of complexity
- Compose a reference panel
- Create the feedback
- Make decisions related to on-line learning platforms.

Theoretical underpinning

LbC stems from a theory that is at the core of a cognitive perspective on learning: the script theory. On the heels of the Second World War and the development of computers leading to their wider availability in the 1960s, learning has been associated with evolving data structures in long-term memory, named scripts. The basic idea is that scripts constitute a fluid network of specific knowledge that becomes activated when certain stimuli in the environment are present. Confronted by a given situation, the human mind naturally generates hypotheses aimed to understand the situation and act appropriately based on these scripts (Abelson 1975; Schank and Abelson 1977). Information, spontaneously or deliberately collected in the context, is interpreted and leads to strengthening or weakening of the initial hypotheses and, ultimately, to accept or reject it. This relies upon the natural capacity of the brain to make micro-judgments, quickly and almost unconsciously.

Applied to clinical reasoning (Charlin et al. 2000; Charlin et al. 2007), script theory allows an understanding of how professionals proceed in their quest to understand the health situation presented to them. When situations are sufficiently categorized, options for action (investigation, treatment) arise and are treated cognitively in a similar way. Knowledge networks used in health professions are called illness scripts (Feltovich and Barrows 1984). Stored in long-term memory, they are made up of any data about a given illness learned by the individual. Training in clinical reasoning consists of the act of building these illness scripts so that they contain increasingly more information about the illness, including knowledge derived from experience. The basic premise is that the more these networks are knowledge-rich, and the more that the clusters or links between knowledge are active and used, the more the health professional will be a good clinician (Charlin et al. 2000; Charlin et al. 2007) or an expert nurse (Deschênes and Goudreau 2017).

While the task of developing these networks is the responsibility of the learner, instructors can conceive educational activities to support the building of links within scripts, ensuring that knowledge that is being added to a learner's network is carefully indexed so as it to make it readily available to apply in a clinical situation (Dory et al. 2012; Custers 2015; Lubarsky et al. 2015). It is on the basis of these theoretical considerations that the LbC strategy was developed (Foucault et al. 2015; Fernandez et al. 2016; Lecours et al. 2018; Deschênes et al. 2020). It was innovative in two ways, first by using a format of questioning that mimicked the way clinicians interpret data once hypotheses are activated and second by allowing the participants to see how well their answers concord with those of a reference panel. This combination of just-in-time delivery of specific knowledge about a given illness provides a powerful way to develop appropriate illness scripts.

LbC is a form of cognitive apprenticeship (Brown et al. 1989; Lave and Wenger 1991), a process whereby students gradually progress towards mastery of a given task with the help of instructors who initially demonstrate how to accomplish the task, and gradually fade away as they allow the learner to perform it. This constitutes a sort of scaffolding that is important at the beginning of training but is progressively removed as the student gains

confidence and mastery. With LbC, learners can see how "concordant" their answers are with those of a reference panel. Students can therefore calibrate the quality of their reasoning and because panel members are asked to explain their answers, the learner has access to the reasoning or rationale behind their responses. This confirms that the reasoning the student is developing is appropriate, or when it is not, provides corrective feedback.

We will now describe the stages and issues to consider when designing a LbC tool. They will be illustrated by examples from various professions: medicine, nursing, physiotherapy and dentistry. These stages and issues are: 1) the principles of questioning and of concordance, 2) the nature of the reasoning task, 3) designing learning material, 4) constituting a reference panel, and 5) the need for on-line learning platforms.

Principles of questioning and of concordance

Questioning:

The LbC educational strategy aims to mimic thinking processes in terms of scripts. A vignette describes a clinical situation in a few lines (which can be accompanied by images, sounds or video recordings). It is followed by questions that experienced health professionals would ask in the same situation. An hypothesis or option is proposed, then new information is delivered. As script theory postulates, reasoning consists of a series of qualitative micro-judgments made on situational data. The participant is asked to rate the degree to which the new information alters the initial hypothesis. The answer is captured on a Likert scale (Figure 1). Each question is independent and the data is not cumulative from one question to another.

Figure 1 presents the questions in the format. The top row contains the clinical situation in 2 to 3 sentences. Then the three columns contain, from left to right the three stages of the LbC Process. The option or hypothesis - *if you think*...- related to the clinical situation; The new information - *and then you find*...and; the Micro-judgment showing a Likert scale to rate the propensity to alter the initial hypothesis - *The effect on your hypothesis is*.... Each clinical situation can include multiple options or hypotheses, on separate rows.

Figure 1. LbC format including the stages of the LbC Process

Clinical situation (2-3 sentences) [...]		
If you think …	And then you find....	your hypothesis (or option) becomes
[Hypothesis or option...]	[New information…]	☐ Strongly weakened; ☐ Weakened; ☐ Unchanged; ☐ Reinforced; ☐ Strongly reinforced

Concordance:

Health professionals' illness scripts are a result of previous learning and clinical experiences and reflect the variability of problem-solving (Charlin et al. 2000; Charlin et al. 2007). Thus, in the face of clinical problems, there is not always a simple and familiar answer. The concordance approach takes into account that interpretative differences are very common, even within a group of experts. A reference panel made up of seasoned professionals in the field is asked to complete the same reasoning tasks and questions and this provides a baseline on which learners can contrast their responses.

Concordance tools are based on the contrasting of participant and panelist answers. Interpretation of the data made by the participant is compared with that made by experienced professionals. This comparison can be useful both for assessment and learning because the degree of concordance between responses can be used to assess mastery or identify gaps in learning.

Goals: assessment or learning?

If the goal is to assess, a score that is a function of the number of panelists who responded like the participant is produced. Script Concordance Tests (SCT) are made up of a series of such questions. There is an abundant literature on this subject presented for instance in the SCT AMEE Guide (Lubarsky et al. 2013). As this is not the focus of the present guide, we will not delve any deeper into this subject except to say that on electronic platforms the process can be enriched by a pop-up window that appears on the screen when the participant submits an answer, inviting her to explain her response, thereby revealing her reasoning process. This access to reasoning processes can, for example, be used in an oral exam or in a selection interview to explore the problem-solving strategies used by students (Goudreau et al. 2014; Dumont et al. 2015; Tedesco-Schneck 2019; Deschênes et

al. 2020). It could also be used for a written reflection and a debriefing session after completing some questions (Power et al. 2016; Wan et al. 2020).

If the goal is learning, panelists are asked not only to give their answer to each question on the Likert scale but also provide brief justifications for each answer (three, four lines maximum). When the participant answers the question, they see how the panelists respond, but also read the justifications which make a rich contextual knowledge about the situation. This process gives participants a double automated feedback and constitutes the gist of the Learning-by-concordance (LbC) (Foucault et al. 2015; Fernandez et al. 2016; Lecours et al. 2018; Deschênes et al. 2020) tool, the focus of the present AMEE Guide.

Nature of the reasoning task

LbC activities can be very diverse, depending of the field of application. In the most commonly used format (Charlin and Van der Vleuten 2004) (Figure 2) participants are presented with a problematic situation described succinctly. Then, an option relevant to the situation is presented (*if you think about* ...), then new information is provided (*and you find* ...). The participant's task is then to make a micro-judgment (*the effect on your option is* ...). Figure 2 shows the modes of questioning for clinical reasoning with a question of a) physiotherapy; b) nursing; and, c) dermatology. Further below, a fourth example from Dentistry is presented which uses a four-point Likert scale.

Figure 2. **Examples of Reasoning Tasks**

<table>
<tr><th colspan="3">Physiotherapy
(Provided by JP Dumas, pht.)</th></tr>
<tr><td colspan="3">A 71-year-old patient has diffuse pain in the posterior area of the right thigh for more than 6 months, resulting in difficulty walking more than 10 minutes.</td></tr>
<tr><td>If you think …</td><td>And then ....</td><td>The effect on your hypothesis (or option) is:</td></tr>
<tr><td>Spinal stenosis</td><td>You notice normal osteotendinous reflexes in the lower limbs</td><td>☐ Strongly negative;
☐ Negative;
☐ Neutral (no effect);
☐ Positive;
☐ Strongly positive.</td></tr>
<tr><th colspan="3">Nursing sciences
(Provided by MF Deschênes, R.N.)</th></tr>
<tr><td colspan="3">Mr. Buisson, 38 years old, had a cholecystectomy. He received Dilaudid® (hydromorphone) 2 mg PO 3 times since his return from the recovery room. You notice that the patient requires physical stimulation to keep him awake and that he has an embarrassed breathing, like a snore, with a respiratory rate of 10 breaths/min.</td></tr>
<tr><td>If you think …</td><td>And then ...</td><td>This intervention is:</td></tr>
<tr><td>Notify the physician about Mr. Buisson’s condition.</td><td>You notice the following results of a venous blood gas:
pH: 7,25
PCO_2: 52 mmHg
HCO_{3-}: 12 mEq/L</td><td>☐ Strongly contraindicated;
☐ Contraindicated;
☐ Neither more nor less indicated;
☐ Indicated;
☐ Strongly indicated.</td></tr>
<tr><th colspan="3">Dermatology
(Provided by J. Lecours, MD)</th></tr>
<tr><td colspan="3">A 50-year-old man shows up at the clinic with the following non-scaly lesions on the trunk.
 
Photo credit: J, Lecours, MD</td></tr>
<tr><td>If you think …</td><td>And then ....</td><td>The effect on your hypothesis (or option) is:</td></tr>
</table>

Acute urticaria	You have found fixed lesions for more than 48 hours	☐ Strongly negative; ☐ Negative; ☐ Neutral (no effect); ☐ Positive; ☐ Strongly positive.

The Likert scale has, in most cases, five levels ranging from "strongly negative" to "strongly positive", the central point corresponds to "no effect"(Fournier et al. 2008; Giet et al. 2013; Sibert and Fournier 2015). Depending on the context and the questions, Likert's scale anchors can be expressed in other ways (Sibert and Fournier 2015), as the examples in Figure 2 show.

For training on professionalism and ethical judgment (Foucault et al. 2015), the format is slightly different. The task is to make judgments about observed behaviors (Figure 3). The situation that contains a professionalism issue or ethical dilemma, is described briefly and the Likert scale has four points ranging from totally unacceptable to very acceptable. The scale has no median value in order to compel participants to give an opinion on whether or not the described behavior is acceptable (Foucault et al. 2015).

Figure 3. **Questioning format for professional judgment. Example of four-point Likert scale.**

Professionalism (Provided by A. Foucault, MD)
Your resident has prescribed penicillin to an inpatient for an infection. However, in the computerized record of the patient, it is clear that the latter is allergic to penicillin. He received two doses before you realized there was a mistake. The patient remained asymptomatic.
The resident, after you have informed him, changes the prescription, but does not tell the patient.
This attitude is:
☐ Totally unacceptable; ☐ Unacceptable; ☐ Acceptable; ☐ Totally acceptable

Learning material design and development

Content

Numerous published articles describe how to develop SCTs (Fournier et al. 2008; Giet et al. 2013; Sibert and Fournier 2015) and so we will not dwell on that here. We will rather focus on how to build educational material for LbC activities. The steps to follow

are specified in Table 1, but several points must be emphasized for LbC development. When developing a set of problems in a domain there is a need to:

- Identify what are the key elements of reasoning in the domain
- Think of situations that induce reasoning around these issues
- Generate the right combination of hypothesis–new data that will make participants and panelists focus on these key elements
- Write as many questions as there are key elements in a given domain.

This represents a radical change from the way educational material is traditionally built (knowledge acquisition followed by application exercises). This shift in coursework design needs to be explained properly to module developers.

Table 1 summarizes the main stages in designing LbC problems that can generate sufficient insight into reasoning processes that can be contrasted according to concordance principles. Special attention should be paid to stages 4 and 5 as that is where the specific background (stage 4) and contextual cues (stage 5) associated with the reasoning task are embedded into the LbC problem.

Table 1. **Main stages for designing a LbC problems**

1. Identify the audience *(are they students in training or in-practice professionals?)*
2. Assess the learning needs *(what are the key elements or prevailing situations that guide the thinking processes in this field?)*
3. Identify pedagogical intentions, e.g.: do we want to promote learning or evaluate reasoning, or both at the same time *(evaluate to learn?)*
4. Describe the **professional situations** (their number depends on the issue of the field) that will situate the reasoning task in a given practice context and highlight the key elements
5. Generate relevant **assumptions or options** appropriate for the situation (3-4 per situation)
6. Focus on the positive or negative data that could, in this type of situation, reinforce, minimize or reject the assumptions made
7. Construct questions by asking how to combine assumptions and data to get participants thinking about the key elements defined in stage 2
8. Validate the tool developed with 2-3 colleagues

Level of complexity of the targeted learning

In LbC the participant is always, by design, in a problem-solving mode. It is clear that what is a problem for some may not be for others. This is the case, for example, when the problem requires an application of basic knowledge. This may represent a challenge for a beginner while it is not challenging for a more advanced student or an in-service professional. An example from a hematology course in the first year of medicine is shown in Figure 4. In this case, there is no need for a reference panel, the instructor provides the answers and explanations (synthesis message). The aim is to provide students the opportunity to apply knowledge they have just acquired in realistic clinical scenarios. Note that at this level of training, the student is required to apply relevant knowledge with little place for interpretation nuances, therefore the Likert scale has only three levels.

Figure 4. **Hematology - first year of medicine**

A 50-year-old patient presents for consultation. From the lab results, we find a microcytic anemia. (Provided by AM Vincent, MD)		
If you think	And then	The effect on your hypothesis (or option) is:
Anemia of chronic diseases	You notice a lowered ferritin	☐ Negative ☐ Neutral (no effect) ☐ Positive
Answers given by the teacher of the course: Negative		
Synthesis message: Ferritin is an acute phase reactant, i.e., it rises in the presence of acute or chronic inflammatory conditions. In an inflammatory context, iron is sequestered in the reticuloendothelial system		

In contrast, for continuing professional development (CPD) purposes, the problem generally features a greater degree of ambiguity and uncertainty, for example when a patient has several diseases, or the situation requires an interpretation of the rules of good practice. In these far more challenging cases, the Likert scale has five points. Figure 5 presents an example of on-line training for specialists who manage thyroid cancers (Guertin et al. 2019). That LbC tool contained 25 cases (150 questions) and used a 5-point Likert scale. It covered all aspects of this field of practice, from managing asymptomatic nodules to anaplastic, metastatic cancers.

Figure 5. **Thyroid Cancer LbC Tool**

A 42-year-old patient consults because of an asymptomatic left thyroid nodule.		
If you think	And then	The effect on your hypothesis (or option) is:
Perform a thyroid nodule biopsy	You find that the patient is known to have a 3 cm x 2 cm x 1.5 cm nodule that has already had a satisfactory benign cardiopulmonary bypass while the dimensions of the nodule are currently 3.4 cm x 2.7 cm x 1.7 cm.	☐ Strongly negative; ☐ Negative; ☐ Neutral (no effect); ☐ Positive; ☐ Strongly positive.

Reference panel as source of feedback

In LbC the reference panel plays a fundamental role. Hence, participants naturally ask themselves "who are the individuals who pretend giving me feedback on my way of reasoning". To create a reference panel, three questions must be addressed: Who? How many? How to recruit them?

Any member of the panel is, in principle, a professional sufficiently familiar with a given field. The size of the panel depends on the complexity of the reasoning tasks. For basic, first- or second year medical training courses, the reference panel can be composed of a single lecturer. This was the case, for example, in the formative evaluation example given in hematology (Figure 4), where the goal of the LbC tool was to encourage students to apply knowledge that had just been acquired and initiate them to the exercise of clinical reasoning (Fernandez et al. 2016).

In contrast, it has been shown by research that, when high fidelity scores are required, such as high-stake assessment situations aiming to classify students and thus determine their future, it is recommended to have 15 or more panelists (Gagnon et al. 2005). This concerns SCTs. In Continuous Professional Development (CPD), the issue is different. The aim is not to provide a score but to provide feedback. In this respect, it is suggested that the number of panellists be sufficient to reveal slight nuances in reasoning in a particular domain. However, this number should not be excessive, as multiplication or redundancy of responses and justifications may be too wearisome for participants. Therefore, for CPD, panels typically do not include more than seven to eight people.

Because panelists are asked to apply their reasoning skills in situations that are common in their clinical practice, it is generally easier to recruit them as compared to asking them to sit on traditional assessment panels. They do not have to consult reference books or colleagues before answering, rather their spontaneous responses reflecting their

domain-specific experiential knowledge is what is required (Charlin et al. 2018). In their ongoing professional development program for thyroid cancer, Guertin et al. (2019) approached seven people whose expertise is widely recognized across North America and their recruitment was not a problem. For the LbC tool aimed at developing reflexivity on professionalism and ethics for students starting clerkship (Figure 3), Foucault et al. (2015) sent an e-mail to the entire cohort of clerks asking them to name three teachers whose professionalism and ethical approach had particularly impressed them during their training. The panel was made up of the eight most frequently cited teachers.

Panelists' answers and justifications as sources of feedback

Having feedback provided by a reference panel who answered the same questions and justified each of their responses is a strength of LbC. Seeing how their answers concord with those of the panel allows participants to calibrate their reasoning. Unveiling the justifications given by the panel provides access to interpretative nuances among experts and the rationality related to their micro-judgment.

To discover that panelists diverge in their answers and justifications is often a surprise to those who create LbC activities. Experts do vary in their interpretations. When they all agree, it is usually because the question involves unequivocal knowledge (the right lung has three lobes) and does not lead to reflection or provide contextualized knowledge in a given situation (Fournier et al. 2008; Dory et al. 2012; Lubarsky et al. 2013; Sibert and Fournier 2015). Conversely, when the answers and justifications diverge significantly it is usually because the question is confusing or unclear and needs to be rewritten. This difficulty can also arise in cases where a controversial subject has no clear "right" answer, or there is no acceptable consensus, or panellists lack certain data from research and their applications in professional practice (Deschênes et al. 2019).

When panelists write justifications for their answers, they share their experiential learning. It is precious access to this highly contextualized and specialized knowledge (Foucault et al. 2015; Fernandez et al. 2016; Charlin et al. 2018; Lecours et al. 2018). For example, Figure 6 illustrates two diverging comments provided by panellists of professionalism and ethics LbC tool. This tool has a panel of 8 medical educators. In this case, participants were able to compare judgments provided by educators whose professionalism and ethics they valued and appreciated.

Figure 6. **Illustration of divergent panellist comments**

Professionalism
(Provided by A. Foucault, MD) Your resident has prescribed penicillin to an inpatient for an infection. However, in the computerized record of the patient, it is clear that the latter is allergic to penicillin. He received two doses before you realized there was a mistake. The patient remained asymptomatic.
The resident, after you have informed him, changes the prescription, but does not tell the patient.
This attitude is
☐ Totally unacceptable; ☐ Unacceptable; ☐ Acceptable; ☐ Totally acceptable
Comments from panelists
Panellist 1: The patient has the right to know and the doctor has the duty to inform the patient of the incident, as stipulated in the code of ethics of the College of Physicians of Quebec. *Panellist 5:* This is a falsification of the file. This is 1 - probably illegal and 2 - shows a flagrant lack of ethics. This action should be used to illustrate the resident's lack of ethics by using this situation for teaching purposes and to be documented in the resident's academic record.

Educational synthesis

When needed, at the end of a topic for instance, a summary of key points can be provided, written by the course teacher (See the example in Figure 4) or by a person whose expertise in the field is recognized by peers. Recent evidence on best practices are reviewed and presented with hyperlinks to key references and other Web-based resources (Charlin and Fernandez 2016; Charlin et al. 2018).

Given the dual feedback (panelists' answers and their justification), the key points represents a third source of interaction provided when participants have completed a sequence of questions, where they have applied their knowledge and validated the adequacy of their reasoning. It is therefore likely that participants will seek the educational resources that are offered to further explore the subject. As an example, in the professionalism LbC tool presented in Figure 3 and 6, the educational synthesis often directed participants towards specific articles of the Code of law or regulations and their interpretation.

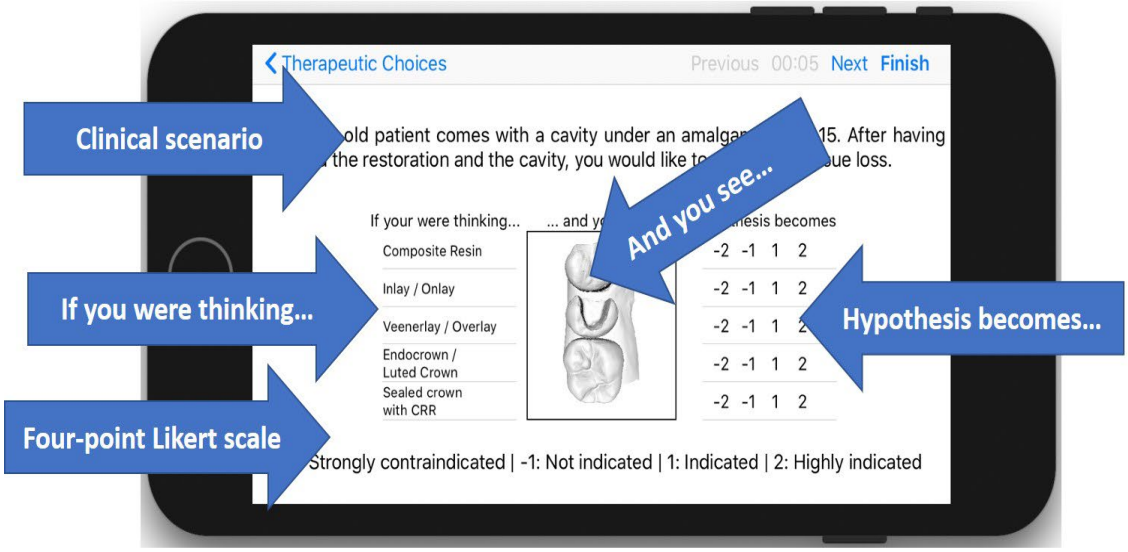
On-line Learning Platforms

It is still possible to make a paper based SCT, but it is rare nowadays as it is cumbersome and makes the calculation and compilation of the results very tedious. For LbC there is no choice, a distance-learning platform is required for synchronous as well as

asynchronous interactions. In both cases the platform will help to design the material (pre-formatted questioning) and display the educational material. In synchronous activities LbC optimizes interactivity in classrooms or workshops. Situations and questions are displayed on the screen. On some electronic platforms (Wooclap®) participants answer questions on their mobile devices and responses are automatically compiled within the slides of the educator, thus providing opportunity to engage in interactive and collaborative face-to-face activities where key messages can be reinforced or discussions can be initiated when responses are varied or even divergent.

With asynchronous activities, several operations can be accomplished directly on the platform, especially those related to collecting panel members' answers and justifications to be introduced in the material that will be communicated to participants. Key points must also be introduced as well as other educational sources, in different media (videos, scorms or TIN CAN files, list of references, hyperlinks, etc.). In addition, online platforms allow for participant registration and follow-up as well as documenting their learning. Furthermore, asynchronous activities can be completed at a pace suitable for each participant. Figure 7 presents a LbC question from the field of Dentistry presented on a smart phone.

Figure 7: Example of LbC distributed on a smart-phone platform
Courtesy of Dr Maxime Ducret, DMD



Companies, such as (Wooclap®, or Theia®) offer tools for doing synchronous or asynchronous online activities. Beside these commercial solutions, universities in Canada and France are collaborating to adapt Moodle®, a multi-language, open-source platform, to develop and administer LbC activities. The common goal is that anyone – anywhere will be able to design and implement LbC activities.

Complementary issues

- Preparing participants

  Because LbC is different from traditional training modes as the knowledge presented is organized according to cognitive structures (scripts) and not structured like in traditional textbooks around topics, learners need to be familiarized with the kind of reasoning (Foucault et al. 2015; Fernandez et al. 2016). Once they get the gist of how the tool works, they are generally enthusiastic about this new way of learning. LbC tool developers also need some training to be familiar with questioning format that characterizes LbC.

- Collective or individual task

  While synchronous material to be used in class can be made by individual educators, more ambitious asynchronous LbC modules may require collaboration of several people. For the large CPD program depicted in Figure 5, five roles were identified: master-designer (coordinates everything), case and question writer, panel members, scientific writers (educational synthesis), training manager (registration, follow-up, reminders, etc.); some of these roles were held by the same person.

- Beyond health professions

  The LbC concept, while initially described in the health professions, can easily be adapted for applications in other domains, provided that professionals apply reasoning in contexts of complexity and uncertainty as opposed to a simple application of technical knowledge and procedures.

Conclusion

LbC represents an innovation that provides learning tools adapted to domains as diverse as clinical reasoning and reflection on ethical or professionalism issues. It can be applied in initial training as well as continuous professional development. It allows for exposure to real life problems and provides automated targeted feedback, with complementary material on key discussion points.

LbC is coherent with a cognitive apprenticeship (Brown et al. 1989; Collins et al. 1991; Lyons et al. 2016), whereby learning is enhanced by panelists' experiential and contextualized knowledge. LbC provides the opportunity to capture this "living knowledge" not found in textbooks but gathered by professionals as they conduct their daily practice (Charlin and Fernandez 2016; Charlin et al. 2018). In this regard, it helps to better understand the nuances and subtleties of reasoning in clinical situations and complement the training tools currently used in health education programs (Fernandez et al. 2016).

An important advantage of LbC training tools is that on-line application enhances its effectiveness. Not only are the participants able to access the training at their convenience, something that is increasingly valued in our post-modern world, they also get access to the contextual guidance afforded by panel member responses and justifications and key messages embedded within the same tool. Furthermore, the variety and quality of technologies available today, at ever-decreasing costs, offer LbC designers and instructors, a wealth of possibilities to create engaging and pedagogically impactful training tools that can be accessed by broader audiences no longer bound by geographical barriers.

The underlying assumption under LbC is that the acquisition of knowledge through clinical situations in that particular format, combined with the exposure to the reasoning of panelists leads to more robust learning, with easier and efficient transfer to practice. This logic of knowledge acquisition is opposed to the one in which the knowledge is exposed in a generic format first, and subsequently applied in exercises.

Contributions

The heart of the article was written by Bernard Charlin. Nicolas Fernandez and Marie-France Deschênes have revised it in depth and provided valuable insights and suggestions. The examples illustrating the article were created by professionals of different disciplines.

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Interest Disclosure

Bernard Charlin is the creator of the concepts of SCT and LbC. He sometimes acts as a consultant to private firms or educational institutions that perform training by concordance. The other authors have no conflict of interest to report in relation to the content of this article.

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