Conceptual frameworks to illuminate and magnify

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CONTEXT In a recent study of the quality of reporting experimental studies in medical education, barely half the articles examined contained an explicit statement of the conceptual framework used. Conceptual frameworks represent ways of thinking about a problem or a study, or ways of representing how complex things work. They can come from theories, models or best practices. Conceptual frameworks illuminate and magnify one's work. Different frameworks will emphasise different variables and outcomes, and their inter-relatedness. Educators and researchers constantly use conceptual frameworks to guide their work, even if they themselves are not consciously aware of the frameworks.

METHODS Three examples are provided on how conceptual frameworks can be used to cast development and research projects in medical education. The examples are accompanied by commentaries and a total of 13 key points about the nature and use of conceptual frameworks.

CONCLUSIONS Ultimately, scholars are responsible for making explicit the assumptions and principles contained in the conceptual framework(s) they use in their development and research projects.

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INTRODUCTION

Glassick's second standard for assessing scholarship calls attention to 'adequate preparation' whereby scholars show their understanding of existing scholarship in the field.[1] Such understanding comes from knowing and critically appraising the literature, including the various conceptual frameworks used. Conceptual frameworks represent ways of thinking about a problem or a study, or ways of representing how complex things work the way they do. Different frameworks will emphasise different variables and outcomes, and their inter-relatedness. For example, if the goal is to design a module on how to learn knot tying in surgery, behaviourism will emphasise practice and performance; cognitivism will highlight mental strategies; social learning theory will emphasise teacher–student and student–student interactions; constructivism will focus on building meaning; and a staged theory of learning will focus on the series of steps in acquiring knowledge and skills. (See, for example, Slotnick and Shershneva.[2]) A holistic approach to designing such a module might combine any number of frameworks. Broadly speaking, conceptual frameworks come from:

- theories with well-organised principles and propositions that have been confirmed by observations or experiments;
- models derived from theories, observations or sets of concepts, or
- evidence-based best practices derived from outcome and effectiveness studies.

Conceptual frameworks are like lighthouses and lenses; hence the illumination and magnification analogies. Whereas the lighthouse illuminates certain parts of the ocean at any given time, other parts are left in the dark. Each framework highlights or emphasises different aspects of a problem or research question, as illustrated above with the various learning theories. Any one conceptual framework presents only a partial view of reality (from Schwab in Harris[3]). By contrast, conceptual frameworks are also like magnifying glasses; each individual framework magnifies certain elements of the problem, such as psychomotor skills with behaviourism compared with mental strategies with cognitivism, or meaningfulness with constructivism. Operating without a conceptual framework or jumping quickly, consciously or not, onto a single framework without exploring others will leave you short-changed, given the range of possibilities available. Other frameworks might cast a different and richer light on the issues at hand.

In a recent study of articles reporting experimental studies in medical education,[4] less than half (45%) contained a critical review of the literature, which often provides conceptual frameworks, and barely more than half (55%) reported a conceptual framework. We all have assumptions, explicit or implicit, about the way things are and how they work. It is the researchers' and authors' responsibility to make those assumptions explicit to the readers and to connect their work to the literature in the field. Most articles reported neither a guiding conceptual framework nor explicit assumptions.

The purpose of this essay is to illustrate the use of and particular illumination provided by various types of conceptual frameworks in developing education and research projects. To do so, imagine that you, as an educator for the health professions education, have been presented with a problem for which you are asked to provide advice on possible solutions or to design a related study. Conceptual frameworks will help you clarify the nature of the problem and guide the development of possible solutions or study questions and designs. Below are three examples of how conceptual frameworks can be used to look at and frame various education problems. Each example is followed by commentaries and key points, 13 in all, about the nature and use of conceptual frameworks. The key points in each example are not unique to that example but apply across examples and situations. The first two examples illustrate the application of conceptual frameworks in development projects in medical education. The third example illustrates the use of conceptual frameworks in research, either to guide the study question and design, to interpret the results, to challenge existing theories, or to build new ones.

EXAMPLE 1. DECLINING ATTENDANCE

The director of continuous professional development (CPD, also known as continuing medical education) at your hospital is worried about declining attendance at the various CPD activities organised for community doctors over the past year. He would like you to look into the problem and propose some solutions. He thinks that it's a venue problem.

The problem presented to you by the CPD director, *declining attendance*, is most likely a symptom of some underlying cause. The director assumes that the decline is caused by the venue. What are some other ways of looking at the situation? A curriculum planning

perspective, such as the six-step approach to curriculum development proposed by Kern *et al.*,[5] can provide a conceptual framework with which to analyse this problem. The elements of the framework are:

- problem identification;
- needs assessment of the learners;
- educational goals and objectives;
- instructional strategies;
- implementation, and
- evaluation and feedback.

The approach taken by Kern *et al.*[5] represents an example of a model comprised of a series of components that were derived overall from systems theory applied to curriculum development.

Bandura's social learning theory would provide another conceptual framework that would highlight 'the importance of observing and modelling the behaviours, attitudes, and emotional reactions of others'.[6] According to Kearsley,[6] the processes underlying observational learning are:

- *attention*, including modelled events and observer characteristics;
- *retention*, including symbolic coding, cognitive organisation, symbolic rehearsal and motor rehearsal;
- *motor reproduction*, including physical capabilities, self-observation of reproduction and accuracy of feedback, and
- *motivation*, including external, vicarious and self-reinforcement.

Social learning theory includes both cognitive and behavioural frameworks.

Let's say that after consideration of the problem and various conceptual frameworks, you chose the curriculum framework of Kern *et al.*,[5] with its six components, to analyse the CPD problem. A brief survey revealed that the main reasons for the decline in attendance were associated with a failure to assess the specific needs of the community doctors and the use of passive instructional strategies during the CPD activities. With these two issues in focus, you could then turn to another conceptual framework, derived from best practice evidence regarding effective instruction, to propose alternative sets of solutions. What do we know about which instructional strategies work best in CPD? Based on analyses of CPD practices carried out by Davis *et al.*,[7,8] the following seven instructional strategies have been shown to work best:

- needs assessment;
- focused initiative;
- interactive instructional methods;
- multiple sessions;
- opportunity for practice and feedback;
- enabling social and organisational support, and
- reinforcement techniques.

You can now use the frameworks of Kern *et al.*[5] and Davis *et al.*[7,8] to prepare not one but two or more alternative solutions from which the CPD director can choose, with each solution highlighting different ways of performing a needs assessment and designing active instructional methods. You may come up with, for example, one solution that involves a mailed needs assessment survey and small-group instruction, and another solution that sets up focus groups for needs assessment and simulation-based sessions for instruction. Once the solutions are ready, you or the programme director can select a preferred solution; more on this later.

This example illustrates four key points about conceptual frameworks. Firstly, the problem presented by the CPD director, namely, declining attendance, was actually a symptom, and his perception of the problem focused only on a single issue, the venue. The nature of the real problem, the root cause, became clearer by using an analysis based on a curriculum framework: in this case, Kern *et al.*'s six-step model[5] derived from systems theory. This conceptual framework offered a way of looking at the problem from a broader and more comprehensive, multi-faceted perspective. Secondly, other conceptual frameworks, such as Bandura's social learning theory, could have been used to illuminate different aspects of the problem or potential solutions. In that case, the analysis of the problem might have focused on participant motivation and the type of participant interactions. Thirdly, various conceptual frameworks offer established foundations from which to readily identify important variables and their potential relationships and provide ways of understanding interactions among variables or interpreting data from studies. Because each conceptual framework is inherently limited, Schwab, in reference to curriculum inquiry, argued for the use of multiple conceptual frameworks in order to view a problem 'through a succession of lenses' (in Harris[3]). Typically, more than one conceptual framework may be relevant to a given situation; for example, Dornan *et al.*'s model of workplace learning[9] incorporates multiple frameworks. Finally, a combination of two conceptual frameworks was used, one to analyse the problem (Kern *et al.*'s steps grounded in systems

theory[5]) and another to guide the development of solutions (Davis *et al.*'s best practices for CPD[7,8]). The conceptual frameworks were helpful in both defining the nature of the problem more clearly and preparing alternative solutions.

Key points

1 Conceptual frameworks help understand (illuminate) problems.
2 Different conceptual frameworks emphasise (magnify) different aspects of the problem or elements of the solutions.
3 More than one conceptual framework may be relevant to a given situation.
4 Any given conceptual framework, or combination of frameworks, can lead to a variety of alternative solutions.

EXAMPLE 2. POOR SURGICAL SKILLS

The cardiothoracic residency programme director is unhappy with the skills level of residents in the operating room. The residents are taking too long to operate and are making too many mistakes. She has asked you to propose some solutions, keeping in mind that her department has already invested in simulation training.

Again, the problem presented to you by the programme director, *too long and too many mistakes*, is actually a symptom of some underlying cause. One way to look at this problem is through the theory of expertise suggested by Ericsson *et al.*, which emphas-

ises deliberate practice with feedback.[10,11] According to Ericsson *et al.*'s theory,[10,11] the learning task should:

- motivate the learner through improvement in *real-life, final performance*;
- take into account the learner's *pre-existing knowledge* (learning curve);
- allow *repetition* of the skills multiple times;
- be accompanied by *immediate feedback*, and
- be *varied* (mixed) across content areas.

Let's assume that further investigation, using this theory of expertise as a conceptual framework, suggested that the root cause primarily represented a lack of practice and direct supervision of skills acquisition. As the department has already invested in simulation training, you can use these five principles to guide the development of two sets of solutions, such as one using a low-fidelity simulation and another using a high-fidelity solution, each incorporating the five task characteristics of Ericsson *et al.*[10,11]

You could, moreover, add a second conceptual framework or set of criteria, also taken from Ericsson *et al.*,[10,11] to help in selecting a preferred solution by trying to minimise three types of constraints: resource allocation, effort required, and possible lack of motivation. To facilitate the decision-making process, you can provide a visual aid, such as a table, to summarise the stakes (Table 1).

In this example, the two frameworks provide ways of conceptualising the problem and formulating possible solutions. In the first example, the conceptual

Table 1   Comparison of two simulation solutions using Ericsson et al.'s conceptual frameworks of expertise[10,11]

	Low-fidelity simulation	High-fidelity simulation
The task should:		
Motivate through real-life, final performance	+	++
Consider resident's pre-existing knowledge	+++	++
Be able to be repeated multiple times	+++	++
Be accompanied by immediate feedback	++	++
Be presented in varied contexts	++	+++
The task should minimise:		
Resource constraints	+++	
Effort constraints	++	++
Motivational constraints	+	+++

framework came from a model (i.e. Kern *et al.*'s six-step approach[5]) derived from systems theory and from best practices (i.e. Davis *et al.*'s best practice in CPD[7,8]) derived from outcomes and effectiveness research. Here, the conceptual framework came from a theory (Ericsson *et al.*'s theory of expertise[10,11]) from which the components, derived from observations and experimentation, can be used to predict outcomes.

It is the scholar's responsibility to go beyond simply citing or paying lip service to a conceptual framework, such as Ericsson *et al.*'s deliberate practice theory of expertise[10,11] or Dewey's experiential learning theory.[12] You must also operationalise and use the set of propositions or principles that accompany the theory or conceptual framework (e.g. Joplin's five-stage model of experiential learning[13]: focus, challenge, action, support and feedback) and show how they illuminate the problem and guide the solutions or designs.

Key points

5   Conceptual frameworks can come from theories, models or evidence-based best practices.

6   Scholars need to apply (not just pay lip service to) the principles outlined in the conceptual framework(s) selected.

EXAMPLE 3. LEARNING DIAGNOSTIC REASONING

The final example is taken from my own work. When I began my research on knowledge organisation in memory and clinical reasoning, I turned to psychology and chose prototype theory, an accepted theory of knowledge organisation at the time, as a conceptual framework. Prototype theory portrays knowledge organisation as categories that have representative (prototypical) exemplars at their centre, that serve as anchor points for the remaining members of the category (e.g. pneumonia, common cold, otitis media and HIV are prototypical exemplars of infections).[14] Based on prototype theory, I hypothesised that representative exemplars of medical categories would be 'recalled faster and more accurately than peripheral members'.[14] The results from four experimental studies with medical students and experienced doctors confirmed these hypotheses.[15] Other researchers, by contrast, used an alternative conceptual framework to explore disease categorisation, namely, the notion of particular instances as anchor points for knowledge in memory, such as patient character-

istics and context of care.[16,17] The two frameworks illustrate how different conceptual frameworks illuminate and magnify certain aspects of the situation and disregard others. For example, different conceptual frameworks highlight different variables, such as family resemblance in prototype theory compared with context characteristics in instance theory, and different outcomes, such as response time versus diagnostic accuracy.

Prototype theory also predicts that prototype formation will be facilitated by early exposure to representative and intermediate-level exemplars (e.g. pneumonia), as distinguished from the broad range of members in a category, and to superordinate classes (e.g. viral or bacterial infections). A follow-up observational study confirmed that prototype formation during organ-system courses was greatest in courses concentrating on fewer and more intermediate-level disorders, leading to the conclusion that 'less is more' when it comes to prototype formation.[14,18]

After this initial foray into knowledge organisation, I became interested in the nature of the relationships that link knowledge in memory.[14] Structural semantics, borrowed from anthropology, provided a better theoretical framework than prototype theory to study the inter-relatedness of knowledge in memory. According to structural semantics, the networks of relationships are represented by dichotomous abstract qualifiers called semantic axes; for example, a *severe, acute, lower right* quadrant abdominal pain related to appendicitis and ectopic pregnancy, whereas a *mild, chronic, upper left* quadrant pain related to stomach, colon, spleen or pancreatic disorders. The relationships, as expressed by abstract qualifiers (*severe–mild, acute–chronic…*), can be readily observed and measured in the clinical discourses of doctors as they work through cases. In a series of think-aloud, qualitative studies for categories of neurological, gastrointestinal, intensive care and rheumatological disorders, the clinicians who exhibited greater diagnostic accuracy and more comprehensive understanding of the clinical issues, be they students or experienced doctors, were those who expressed the greatest and most diversified sets of semantic qualifiers.[19,20] These results eventually led to the expansion of the theory itself by proposing four types of discourse organisation:

- reduced discourses (few semantic qualifiers and short discourses);
- dispersed discourses (few semantic qualifiers but extensive discourses);

- elaborated discourses (many semantic qualifiers and extensive discourses), and
- compiled discourses (many semantic qualifiers and concise discourses).[14,21]

Gruppen et al.[22] showed that diagnostic accuracy is greatly enhanced by considering the correct diagnosis early during the clinical encounter, as early as the chief complaint. They used a staged information-processing model of diagnostic problem solving and errors (i.e. information gathering versus information integration) as their conceptual framework, to which they added Bayes' theorem.[22] In relation to their findings, we hypothesised that diagnostic accuracy would be associated with greater use of semantic qualifiers to characterise the chief complaint. The results of a case-control study[23] showed that indeed diagnostic accuracy was associated with greater use of semantic qualifiers to mentally represent the chief complaint, a result that mirrored findings from mathematics education research[24] showing the key role of abstract problem representation in solving algebra problems.

Although conceptual frameworks can be used to frame a problem or guide solutions, as in the previous examples, this example illustrates how conceptual frameworks can be applied to design studies and to interpret study results, as well as how theories themselves can be challenged. Theories are dynamic entities,[25] as was illustrated in the further classification of clinical discourses according to their semantic content and the extent of the discourses, a new addition to structural semantics at the time. Competing theories, such as abstractions versus instances in prototype theory, emerge and challenge one's own work, leading to new hypotheses and theories. This dynamic interplay constantly helps move the field forward, rather than having it descend into stagnation and dogmatism (see also Bordage[14]). At a broader conceptual level, Eva[26] portrays knowledge organisation and clinical reasoning according to analytical and non-analytical processes, such as deliberate semantic problem representation compared with rapid pattern recognition.

Key points

7 Conceptual frameworks help identify important variables and their potential relationships; this also means that some variables are disregarded.
8 Conceptual frameworks are dynamic entities and benefit from being challenged and altered as needed.

The methodology of qualitative studies illustrates the dual role of conceptual frameworks in framing questions and interpreting results. In a deductive qualitative inquiry, a conceptual framework can be used to formulate the questions and identify important variables to be analysed. In an inductive, grounded theory approach, theories are postulated de novo as the researcher analyses the data.[27–30] The newly formulated theory emerges as a hypothesis to be tested through further qualitative or quantitative studies. In this case, conceptual frameworks and critical appraisal of the literature are used post facto to interpret or contextualise the newly proposed theory. Eventually, the evidence can build up to the level of proposing a theory that can be used for prediction: a theory in scientific terms (e.g. behaviourism, gravity, evolution) embodies an idea or set of ideas that have been confirmed by observations or experiments; in lay terms, however, theories are often considered as hypotheses yet to be proven. Whether they are using conceptual frameworks to frame a problem or to interpret results, scholars are building upon one another's work in ways that allow individual researchers to develop their own programmes of research that lead to explanatory (clarification[31]) studies and deeper understanding that help to move the field forward. Sporadic and opportunistic research, by contrast, runs the risk of being superficial and non-cumulative.

Key points

9 Conceptual frameworks allow scholars to build upon one another's work and allow individuals to develop programmes of research.
10 Programmatic, conceptually based research helps accumulate deeper understanding over time and thus moves the field forward.

The three examples also illustrate how certain conceptual frameworks come from outside one's specialty or domain, such as Ericsson et al.'s theory of expertise[10,11] in psychology and structural semantics in anthropology. Consequently, it is important for scholars in the medical education community to search the literature beyond their clinical specialty and the medical education literature by using search engines such as ERIC or PsychInfo to tap into scholarship on education in general and psychology.

Key point

11 Relevant conceptual frameworks can be found outside one's specialty or field.

CONCLUSIONS

In summary, the main purpose of conceptual frameworks, as illustrated in the examples, is to provide different ways, or 'successive lenses' as Schwab puts it (in Harris[3]), for looking or thinking about a problem or conceptualising solutions. Ultimately, by considering various frameworks, you open yourself up to a variety of alternatives, instead of hastily latching onto one view or some preconceived notion. In turn, the conceptual frameworks provide you with a set of propositions, concepts or best practices that guide you towards articulated, well-grounded solutions, rather than some unique, possibly idiosyncratic or biased approach. By considering multiple conceptual frameworks, you become aware of which options are available and which you will choose to put in and to leave out. Each conceptual framework will amplify certain aspects (the magnifying glass analogy) of the issue at hand while leaving others in the dark (the lighthouse analogy).

Selecting a conceptual framework or a set of frameworks to address your particular problem or situation involves judgement and is a task that can be daunting, especially for novice educators. You may stumble across a framework that seems appealing without realising that other, more appropriate frameworks are available or, more seriously, that this particular framework is flawed or obsolete. Any one conceptual framework is inherently limited in the way it portrays the world and magnifies certain aspects, possibly even distorting other aspects. Before adopting a particular conceptual framework or set of frameworks, it is important to systematically and critically survey the pertinent literature, within and across disciplines, and to carefully examine the relevant evidence that accompanies each framework. Some conceptual frameworks can become obsolete because of a lack of supporting evidence (e.g. learning styles or personality types and their purported impact on learning). The advice of experts in the field can be helpful because they are most likely to know the domain. However, be aware that some experts may have become dogmatic about certain preferred frameworks. Researchers and practitioners can cling to a conceptual framework that self-propagates despite abundant evidence that it really does not work. Reviews and essays that critique each framework will help you make appropriate choices (e.g. Eva's editorial on dangerous personalities[32] and an accompanying paper by Lewis *et al.* on emotional intelligence[33]). With multiple competing frameworks in hand, you are better prepared to fully understand the strengths and limitations of each framework and to judge which framework will best illuminate your problem or situation and minimise possible distortions or avoid compromising flaws.

Conceptual frameworks play an important, essential role in identifying the nature of education problems and in formulating solutions or designing studies. Even if they do not describe them explicitly, educators and researchers constantly use conceptual frameworks, whether theories, models or best practices, to guide their work, even if they themselves are not consciously aware of the frameworks.[34] It was Bernard of Chartres who said [adapted] during the Renaissance: 'If I have seen further, it is by standing on the shoulders of giants.' The giants in this case are the conceptual frameworks. Remember, it is better to stand on a giant's shoulders than in his face! Your conceptual framework is the backbone (or soul) of your project or study. It will dictate, whether you are conscious of it or not, what you choose to do and how you interpret your outcomes and results. Conceptual frameworks help you shed light (illuminate) and enlarge (magnify) the issues at hand. With a better understanding of conceptual frameworks, it is hoped that authors will heed the call to report explicitly and operationally in each and every one of their development and research publications which conceptual frameworks they have used and how they have used them. They owe it to their readers to be better informed about the assumptions and foundations of their work.

Key points

12 Considering competing conceptual frameworks can maximise your chances of selecting the most appropriate framework for your problem or situation while guarding against premature, inappropriate or sub-optimal choices.
13 Scholars are responsible for making explicit in their publications the assumptions and principles contained in the conceptual framework(s) they use.

REFERENCES

1 Glassick CE. Boyer's expanded definition of scholarship, the standards of assessing scholarship, and the elusiveness of the scholarship of teaching. *Acad Med* 2000;**75**:877–80.

2 Slotnick HB, Shershneva MB. Use of theory to interpret elements of change. *J Contin Educ Health Prof* 2002;**22**:197–204.

3 Harris I. Deliberative inquiry: the arts of planning. In: Short EC, ed. *Forms of Curriculum Inquiry.* Albany, NY: State University of New York 1991;285–307.

4 Cook DA, Beckman TJ, Bordage G. Quality of reporting experimental studies in medical education: a systematic review. *Med Educ* 2007;**41**:735–45.

5 Kern DE, Thomas PA, Howard DM, Bass EB. *Curriculum Development for Medical Education: a Six-step Approach.* Baltimore, MD: Johns Hopkins University Press 1998;4–7.

6 Kearsley G. Social learning theory (A Bandura). In: *Explorations in Learning and Instruction: the Theory into Practice Database.* http://tip.psychology.org/bandura. html. [Accessed 18 July 2008.]

7 Davis DA, Thomson MA, Oxman AD, Haynes RB. Changing Physician Performance. A systematic review of the effects of continuing medical education strategies. *JAMA* 1995;**274**:700–5.

8 Davis DA, O'Brien MA, Freemantle A, Wolf FM, Mazmanian P, Taylor-Vaisey A. Impact of formal continuing medical education: do conferences, workshops, rounds, and other traditional continuing education activities change physician behaviour or health care outcomes? *JAMA* 1999;**282**:867–74.

9 Dornan T, Boshuizen H, King N, Scherpbier A. Experience-based learning: a model linking the processes and outcomes of medical students' workplace learning. *Med Educ* 2007;**42**:84–91.

10 Ericsson KA, Krampe RT, Tesch-Römer C. The role of deliberate practice in the acquisition of expert performance. *Psychol Rev* 1993;**100**:363–406.

11 Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med* 2004;**79** (Suppl):70–81.

12 Dewey J. *Experience and Education.* New-York: Simon and Schuster 1938(1997), 96 pp.

13 Joplin L. On defining experiential education. *J Experiential Educ* 1981;**4**:17–20.

14 Bordage G. Prototypes and semantic qualifiers: from past to present. *Med Educ* 2007;**41**:1117–21.

15 Bordage G, Zacks R. The structure of medical knowledge in the memories of medical students and general practitioners: categories and prototypes. *Med Educ* 1984;**18**:15–25.

16 Allen SW, Norman GR, Brooks LR. Experimental studies of learning dermatologic diagnosis: the impact of examples. *Teach Learn Med* 1991;**4**:35–44.

17 Hatala R, Norman GR, Brooks LR. Influence of a single example upon subsequent electrocardiogram in terpretation. *Teach Learn Med* 1999;**11**:110–7.

18 Bordage G. The curriculum: overloaded and too general? *Med Educ* 1987;**21**:183–8.

19 Bordage G, Lemieux M. Semantic structures and diagnostic thinking of experts and novices. *Acad Med* 1991;**66** (Suppl):70–2.

20 Lemieux M, Bordage G. Propositional vs. structural semantic analyses of medical diagnostic thinking. *Cogn Sci* 1992;**16**:185–204.

21 Lemieux M, Bordage G. Structuralisme et pédagogie médicale: étude comparative des stratégies cognitives d'apprentis-cliniciens. [Structuralism and medical education: a comparative study of the cognitive strategies of novice physicians.] *Recherches Sémiotiques [Semiotic Inquiry]* 1986;**6**:143–79.

22 Gruppen LD, Wolf FM, Billi JE. Information gathering and integration as sources of error in diagnostic decision making. *Med Decis Making* 1991;**11**:233–9.

23 Chang R, Bordage G, Connell K. The importance of early problem representation during case presentation. *Acad Med* 1998;**73** (Suppl):109–11.

24 Brenner ME, Mayer RE, Moseley B, Brar T, Duran R, Smith-Reed B, Webb D. Learning by understanding: the role of multiple representations in learning algebra. *Am Educ Res J* 1997;**34**:663–9.

25 Norman GR. Theory-testing research versus theory-based research. [Editorial.] *Adv Health Sci Educ* 2004;**9**:175–8.

26 Eva KW. What every teacher needs to know about clinical reasoning. *Med Educ* 2004;**39**:98–106.

27 Harris I. What does 'The discovery of grounded theory' have to say to medical education? *Adv Health Sci Educ* 2003;**8**:49–61.

28 Kennedy T, Lingard L. Making sense of grounded theory. *Med Educ* 2006;**40**:101–8.

29 Lingard L. Qualitative research in the RIME community: critical reflections and future directions. *Acad Med* 2007;**82** (Suppl):128–30.

30 Reeves S, Albert M, Kuper A, Hodges B. Why use theories in qualitative research? *BMJ.* 2008;**337**:631–4.

31 Cook DA, Bordage G, Schmidt H. Description, justification, and clarification: a framework for classifying the purposes of research in medical education. *Med Educ* 2008;**42**:128–33.

32 Eva KW. Dangerous personalities. [Editorial.] *Adv Health Sci Educ* 2005;**10**:275–7.

33 Lewis NJ, Rees CE, Hudson JN, Bleakley A. Emotional intelligence in medical education: measuring the unmeasurable? *Adv Health Sci Educ* 2005;**10**:339–55.

34 McGaghie WC, Bordage G, Shea JA. Problem statement, conceptual framework, and research question. *Acad Med* 2001;**76**:923–4.