iSIM® Improving Simulation Instructional Methods

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Journey to Simulation

课程研发机构：
迈阿密大学Gordon Center
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iSIM

Improving Simulation

Instructional Methods

JTS Pre-course Material 课前学习资料

iSIM 模拟之路

课前学习资料列表

1. 成人学习理论（Adult Learning Theory）拓展阅读
2. 掌握性学习（Mastery Learning）拓展阅读
3. 医学教育最佳证据（BEME）4 号指南（2007 年更新精要版）
4. 结构化支持性 Debriefing 拓展阅读（《模拟医学》教材第 6 章）
5. Debriefing 方法之 G-A-S 架构——纲要与辅助工具
6. 《模拟医学》教材说明
7. 模拟医学英文术语及解释

关于 iSIM 课程

课程概况

iSIM 系列课程是美国匹兹堡大学 WISER 中心与迈阿密大学 Gordon 医学教育研究中心共同研发国际知名的模拟教育师资培训（Train-the-trainer）课程课程。

课程系列从最基础的带教技巧、设计教案、引导性反馈、评估工具使用、团队协作、到导师胜任能力培养，教育研究方面提供方法性的培训。课程的训练目标是想借由课程讲授与实作练习，让欲从事模拟教学及医学教育的教师拥有相关的技巧与能力。并让模拟教学从业人员，从掌握教学能力到熟练，从实际运用到理论教学、团队合作、教学研究，都有更深刻的认知。

系列课程坚持小班教学，是因为想要让学员有最大程度的参与，在课中充分发挥各学员能动性，然后导师根据各人的表现进行引导发馈。理论与实践结合的课程培训设计，将对从事模拟教学的教师有非常实际性的帮助。

课程结束后将由美国匹兹堡大学 WISER 中心与迈阿密大学 Gordon 医学教育研究中心联合签署颁发的的证书。

模拟之路（JTS）

作为模拟教学的入门级课程，该课程主要介绍模拟教学的精要，包括在 brief、simulation facilitation 及 debriefing 三个环节的模拟教学授课技巧等。适用于刚接触模拟教学的初学者。

培训采取集中授课、教学示范和教学实践相结合、互动交流相结合等多元化方式，帮助学员逐步理解和掌握模拟教学的内涵，提升模拟教学能力。

完成该课程学习的人员，在接受模拟教学实践的督导后，应规律性开展模拟教学实践。有志于从事模拟教学案例设计与开发的人员，推荐继续参加 iSIM Fundamentals 课程的学习。

JTS 模拟之路”（Journey To Simulation）

课程表

时间		授课主题
第一天	08:30-08:45	课程介绍 Introduction
	08:45-09:45	医学模拟教学的要素 Essentials of Healthcare Simulation Education
	09:45-10:35	如何成为一位医学模拟教学的师资 How to became a Healthcare Simulation Instructor
	10:35-10:45	茶歇 Tea Break
	10:45-11:25	医学模拟教学的教具种类 Different Healthcare Simulation Modalities
	11:25-12:15	医学模拟教学在临床中的应用 Application of Healthcare Simulation in Clinical Practices
	12:15-13:15	午餐 Lunch
	13:15-14:15	医学模拟教学师资能力培训-课前介绍 How to Brief A Simulation Course
	14:15-14:30	茶歇 Tea Break
	14:30-15:30	医学模拟教学师资能力培训-课中引导 How to Facilitate A Simulation Course
	15:30-16:40	医学模拟教学师资能力培训-课后反馈 How to Perform Simulation Debriefing
	16:40-17:15	综合讨论 Discussion & Day 1 Wrap-up

时间		授课主题
第二天	08:30-09:00	第一天课程内容回顾 Review of Day 1 Contents
	09:00-10:20	课前介绍环节的实践练习（分组） Practice on Briefing A Simulation Course (Group Session)
	10:20-10:40	茶歇 Tea Break
	10:40-11:40	课中引导环节的实践练习（分组） Practice on Facilitating A Simulation Course (Group Session)
	11:40-12:00	课后反馈环节的要点 Essentials of Debriefing
	12:00-13:00	午餐 Lunch
	13:00-14:30	课后反馈环节的实践练习（分组） Practice on Simulation Debriefing (Group Session)
	14:30-14:45	茶歇 Tea Break
	14:45-16:45	综合演练考核 Assessment of Simulation Instruction Skill
	16:45-17:15	综合讨论 Discussion & Course Wrap-up

注：以上所有内容均由 iSIM 系列课程认证主任导师及导师进行讲授。

2013; 35: e1561–e1572 MEDICAL TEACHER

WEB PAPER
AMEE GUIDE

Adult learning theories: Implications for learning and teaching in medical education: AMEE Guide No. 83

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Abstract

There are many theories that explain how adults learn and each has its own merits. This Guide explains and explores the more commonly used ones and how they can be used to enhance student and faculty learning. The Guide presents a model that combines many of the theories into a flow diagram which can be followed by anyone planning learning. The schema can be used at curriculum planning level, or at the level of individual learning. At each stage of the model, the Guide identifies the responsibilities of both learner and educator. The role of the institution is to ensure that the time and resources are available to allow effective learning to happen. The Guide is designed for those new to education, in the hope that it can unravel the difficulties in understanding and applying the common learning theories, whilst also creating opportunities for debate as to the best way they should be used.

Introduction

The more we read, the more we realise that there are many different ways of explaining how adults learn (Merriam et al. 2007). None of the individual theories fully explain what is happening when an aspiring health professional is engaged in learning. In this Guide, it will become clear that the authors hold a broadly constructivist view. Constructivists, like Vygotsky (1997), consider that learning is the process of constructing new knowledge on the foundations of what you already know. We will explain a constructivist schema, which we feel has an evidence base and forms a theoretical basis to help curriculum development, learning and teaching strategies, student assessment and programme evaluation.

Malcolm Knowles (1988) considered that adults learn in different ways from children. He introduced the term "andragogy" to differentiate adult learning from pedagogy; this differentiation now seems to be artificial. Many of the principles of andragogy can be applied equally to children's learning. It is probably more appropriate to think in terms of a learning continuum, which stretches throughout life, with different emphases, problems and strategies at different times.

In this Guide, we will indicate what we feel are the main types of learning theories, show briefly the way in which the theories have developed from each other, and then show how, and when, different theories can be applied to maximise learning.

When we consider medical education in particular it is important to remember that in some programmes the learners have already completed a university degree, and in others the students come straight from high or secondary school. Medical education also includes postgraduate studies and continuing professional development. Each of our students will have their own individual constraints, experiences and preferences. The educator's task is to provide an environment and the resources in which each learner can flourish.

Practice points

- Becoming a member of a healthcare profession not only demands the acquisition of knowledge and skills, but also involves a process of growing into the professional community.
- Although people learn in different ways, we all run through a process of working out what the possible explanations are and sorting them into probable and less probable, on the basis of reflecting on feedback, our existing experience and knowledge.
- Through understanding the ways in which people learn we can plan the most effective ways in which we can help them to learn.
- The model presented here gives a scheme and a checklist that we can use to increase our effectiveness in organising curricula, delivering education and assessing the outcomes.

Categories of adult learning theories

Our task is complicated by the observation that the theories of learning flow partly from psychological theories of learning

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and partly from pragmatic observation. It is also important to remember that "learning" includes the acquisition of three domains: knowledge, skills and attitudes; any theories should ideally account for learning in each of these three domains.

In broad terms, theories of adult learning can be grouped into, or related to, several categories. There is quite a lot of overlap between the theories and the categories of theories, and here we give a simplified overview:

(a) ***Instrumental learning theories*:** These focus on individual experience, and include the behaviourist and cognitive learning theories.

(i) Behavioural theories are the basis of many competency based curricula and training programmes (Thorndike 1911; Skinner 1954). A stimulus in the environment leads to a change in behaviour. Applying these theories usually results in learning that promotes standardisation of the outcome. This leads to the main issue with behavioural theories – namely who determines the outcomes and how they are measured?

(ii) Cognitive learning theories focus learning in the mental and psychological processes of the mind, not on behaviour. They are concerned with perception and the processing of information (Piaget 1952; Bruner 1966; Ausubel 1968; Gagne et al. 1992).

(iii) Experiential learning has influenced adult education by making educators responsible for creating, facilitating access to and organising experiences in order to facilitate learning; both Bruner's (1966) discovery learning and Piaget's (1952) theory of cognitive development support this approach. Experiential learning has been criticised for focusing essentially on developing individual knowledge and limiting the social context (Hart 1992). Its application in medical education is relevant because it focuses on developing competences and practising skills in specific context (behaviour in practice: Yardley et al. 2012).

(b) ***Humanistic theories*:** These theories promote individual development and are more learner-centred. The goal is to produce individuals who have the potential for self-actualisation, and who are self-directed and internally motivated.

(i) Knowles (1988) supported this theory by popularising the concept of "andragogy". Although it explains the motivation to learn, its main limitation is the exclusion of context and the social mechanism of constructing meaning and knowledge. We now know that context and social factors are crucial in professional education (Durning & Artino 2011).

(ii) Self-directed learning suggests that adults can plan, conduct, and evaluate their own learning. It has often been described as the goal of adult education emphasising autonomy and individual freedom in learning. Although it is axiomatic to adult learning, there are doubts about the extent to which self-directed learning, rather than directed self-learning is truly achievable (Norman 1999;Hoban et al. 2005). A limitation of the concept is failure to take into consideration the social context of learning. It has also implicitly underestimated the value of other forms of learning such as collaborative learning.

(c) ***Transformative learning theory:*** Transformative learning theory explores the way in which critical reflection can be used to challenge the learner's beliefs and assumptions (Mezirow 1978, 1990, 1995) The process of perspective transformation includes

(i) A disorienting dilemma which is the catalyst/trigger to review own views/perspectives – "knowing that you don't know"

(ii) The context, which includes personal, professional and social factors

(iii) Critical reflection. Mezirow (1990) identifies different forms of reflection in transformation of meanings, structures, context, process and premise. Premise reflection involves the critical re-examination of long held presuppositions (Brookfield 2000).

(d) ***Social theories of learning:*** The two elements that are crucial to social theories of learning are context and community (Choi & Hannafin 1995; Durning & Artino 2011). These concepts have been developed by Etienne Wenger (Lave & Wenger 1991; Wenger 1998), who emphasises the importance of "communities of practice" in guiding and encouraging the learner. Land and colleagues consider the way that learners enter the community of practice (Land et al. 2008). The way in which a learner's experience is shaped by their context and community is developed by situativity theory and is discussed by Durning & Artino (2011). Situated cognition theories are based on three main assumptions:

(i) Learning and thinking are social activities

(ii) Thinking and learning are structured by the tools available in specific situations

(iii) Thinking is influenced by the setting in which learning takes place (Wilson 1993).

(e) ***Motivational models:*** Any theoretical model that attempts to explain and relates adult learning to an educational theory must have two critical elements – motivation and reflection. One such theory is self-determination theory (Ryan & Deci 2000; ten Cate et al. 2011; Kusurkar & ten Cate 2013). The theory recognises the importance of intrinsic motivation, and considers that three basic needs must be fulfilled to sustain it: Autonomy, Competence, and a feeling of belonging – or "Relatedness".

(i) One of the issues about learning is that a low expectation of success will result in poor motivation to learn, unless the perceived value of success is overwhelming. This is partly explained by Maslow's theory of needs (Maslow 1954; Peters 1966), but it probably does not capture the balance between the different competing drives of hopes and expectation of learning as opposed to the time and effort needed to engage with the process. The expectancy valence theory (Weiner 1992) incorporates the "value" of success and expectancy of success.

$$\text{Motivation to learn} = \text{Expectancy of success} \times \text{Value of success.}$$

(ii) The Chain of Response model concerns participation by adults in learning projects (Cross 1981). In this model three internal motivating factors are inter-related: self-evaluation, attitude of the learner about education and the importance of goals and expectations. The main external barriers to motivation are life events and transitions, opportunities, and barriers to learning or obtaining information.

(f) ***Reflective models*:** The reflection-change models consider that reflection leads to action and then change. Reflective learning (Schön 1983, 1987) has important relevance to medical education, and more widely in society (Archer 2012). The role of deliberate practice (Duvivier et al. 2011), using reflection and feedback as tools to develop both knowledge and skills is starting to provide very valuable insights for educators helping students develop autonomous learning.

Even this brief consideration of types of theory applicable to adult learning will lead one to realise that they each have their strengths, and are each incomplete without the others. Before addressing a model that attempts to draw the theories together, we need to consider how we arrived at where we are.

Historical aspects of adult learning theories

In the late seventeenth century, the pervading view was that all knowledge derives from experience. Although he personally did not use the term, John Locke (Locke 1690) considered that the mind was a *tabula rasa* or "blank slate" at birth and that all acquired knowledge was derived from experience of the senses. These ideas were reworked and developed until the early twentieth century when Edward Thorndike derived his laws (Thorndike 1911), principally the law of effect – which stated that learning occurred if it had a positive effect on the individual, and the law of exercise – which meant that repetition strengthened the learning.

This was further developed by behaviourists, such as Skinner (1954) who demonstrated that some forms of learning could be demonstrated by a simple stimulus-response paradigm, so that a reward could be used to ensure an appropriate response to a stimulus. Skinner showed that there were three elements that strengthened learning, namely frequency (the number of times a stimulus was presented), contiguity (the time delay between the response and the reward) and contingency (the continued link between the stimulus and the reward). Chomsky (1975) considers that the type of experiments favoured by behaviourists do not explain the acquisition of higher order skills, such as the learning of language. Chomsky argued that our brains are programmed to acquire higher order skills, which we develop and modify by experience. While some were looking at the potential neural mechanisms that underlie the acquisition of learning, others were considering the factors that can make it more effective.

Piaget, a cognitive constructivist, considered the different types of knowledge that could be acquired at different stages in a young person's life (Piaget, 1952). This stream of thought continues to the present day in the work of people like William Perry (1999) who studied the way in which college students change from dualism (ideas are either true or false; teacher is always right) to multiplicity (truth depends on context; teacher is not necessarily the arbiter).

Social constructivists, like Vygotsky (1978) focus on the way that the learning community supports learning. A key idea in social constructivism is that of the Zone of Proximal Development, whereby a learner can only acquire new knowledge if they can link it in with existing knowledge. Conversations between learners/teachers articulating what is already known can extend the zone of proximal development by putting new ideas in the context of current understanding. This strand of thought has been taken forward in social learning theories by Bandura (1977), and in a remarkable way by Wenger in the concept of learning communities or "Communities of Practice" (Wenger 1998).

Andragogy and pedagogy: Knowles views and related learning models

Towards the end of the twentieth century, there was a body of research that suggested that adults learn differently from children and that "andragogy" was a better term for this process than "pedagogy". The key difference between adults and children is said to be that adults are differently motivated to learn. Although the arguments no longer seem quite so clear, the line described by Knowles (Knowles et al. 2005) was that adult learners differ from child learners in six respects:

(1) The need to know (*Why do I need to know this?*)
(2) The learners' self-concept (*I am responsible for my own decisions*)
(3) The role of the learners' experiences (*I have experiences which I value, and you should respect*)
(4) Readiness to learn (*I need to learn because my circumstances are changing*)
(5) Orientation to learning (*Learning will help me deal with the situation in which I find myself*)
(6) Motivation (*I learn because I want to*)

These observations, in association with David Kolb's experiential learning model ((Kolb 1984), see Figure 1) have allowed the consideration of learning and teaching strategies appropriate for adult learners.

In Kolb's scheme, the learner has a concrete experience, upon which they reflect. Through their reflection they are able to formulate abstract concepts, and make appropriate generalisations. They then consolidate their understanding by testing the implications of their knowledge in new situations. This then provides them with a concrete experience, and the cycle continues. Learners with different learning preferences will

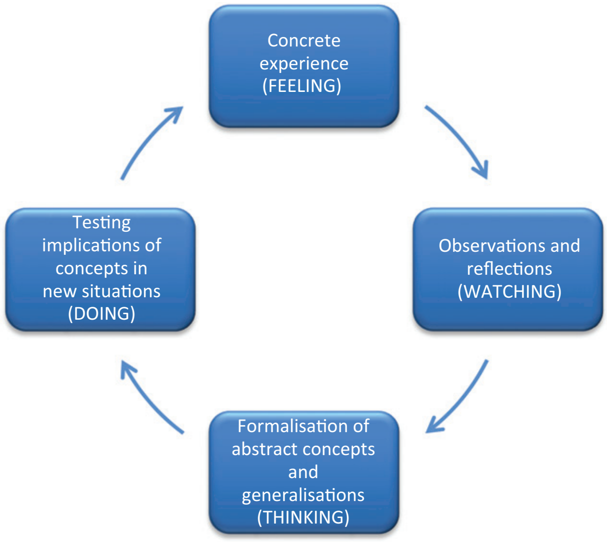

Figure 1. The Kolb Cycle after (Kolb 1984).

have strengths in different quadrants of the (Kolb) cycle. In Kolb's terminology "Activists" feel and do, "Reflectors" feel and watch, "Theorists" watch and think and "Pragmatists" think and do. From the educator's point of view it is important to design learning activities that allow the cycle to be followed, engaging each of the quadrants. Although it is often quoted, and easily understood, the learning style inventory developed from the Kolb cycle has poor reliability and validity (Coffield et al. 2004).

Of particular importance to those who follow a broadly constructivist line (but lacking in the original model), will be the prior experience/knowledge of the individual, and the dissonance between this and the concrete experience that is provided as the learning opportunity. When we see something new, attend a lecture, or talk with a patient, we compare what we are seeing with what we already know, and reflect upon the difference (***reflection in action***, (Schön 1983)). This enables us to formulate abstract concepts that make sense of the new data. In turn this will lead us to propose tests of our knowledge, through direct experimentation or through debate and discussion. This is a familiar process to all acquainted with the scientific/clinical method; however at least one key element is missing, and this is **reflection *on* action**. It is crucial that the learner thinks about the processes they have used, and the extent to which they were rigorous or appropriate in the use of the material; this is fundamental to learning.

The next issue is the way in which new knowledge becomes integrated into the existing knowledge base. Proponents of the transformative learning approach consider that meaningful learning occurs when connections are made between new and existing information (Regan-Smith et al. 1994). Norman & Schmidt (1992) suggest that there are three main elements to this process: elaboration, refinement and finally restructuring. Elaboration is linking in new knowledge with what we already know. It is important, however, that the linkages are precise rather than general (Stein et al. 1984). Refinement is the act of sifting and sorting through the information to retain those elements that make sense. Finally, restructuring is the development of new knowledge maps (schemata) which arguably allow one to become an expert or demonstrate expertise (Norman et al. 2006).

Learning outcomes and scaffolding from Bloom's taxonomy to Miller's pyramid

The processes of acquiring new knowledge, relating it to what is already known and developing new understanding is complicated and difficult but educators can help the learners by providing advance organisers (Ausubel 1968). There are two types of advance organisers: models and metaphors, which we will consider later, and scaffolding.

Scaffolding refers to the structural things that teachers do to guide learners through the teaching and learning material. They are necessary because the sheer volume and complexity of knowledge to be acquired often leaves the learner standing on the threshold (in a state of liminality), rather than stepping into the world of learning.

It is easy to underestimate the problem of liminality. It is described well by Ray Land (Land et al. 2008; Meyer et al. 2010), but it refers to the sense of discomfort we feel when we do not quite understand the rules or the context of a new situation. We need someone to lead us over the threshold, introduce us to the new ideas, and probably explain some of the language (Bernstein 2000). As we start to build our knowledge and understanding, we need to have some idea of where things fit, how they fit together, and some idea of how the individual pieces are part of a greater whole. "Scaffolding" provides that perspective. Scaffolding includes programme level organisers, which are dependent on both the content and the context in which it is being learned. Programme organisers include the syllabus, lectures, planned experiential learning and reading lists. Most commonly, these days scaffolding includes providing learners with a list of intended learning outcomes. It is important to remember that it also includes the induction that students receive when they enter the programme or a new clinical environment.

Learning outcomes can be further refined using Bloom's taxonomy (Bloom et al. 1956), which has been revised by several authors, including Anderson (Anderson & Kratwohl 2001). In Figure 2, Bloom's taxonomy is shown in the pyramid itself, and Anderson's development of it in the side panels.

Anderson's modifications indicate a belief that "creating" is a higher attribute than "evaluating", but they are also important in emphasising that the learner does things with knowledge. Learning outcomes, therefore, should be associated with verbs, rather than lists of things to learn. The difficulty with the model is highlighted by the differences between Bloom and Anderson's model. In reality, the elements of the pyramid are arranged in a cycle. Evaluation leads to developing a new idea which is then applied, analysed, evaluated and so on.

Bloom's original work led to several variants. In medical education, the most frequently encountered is Miller's pyramid

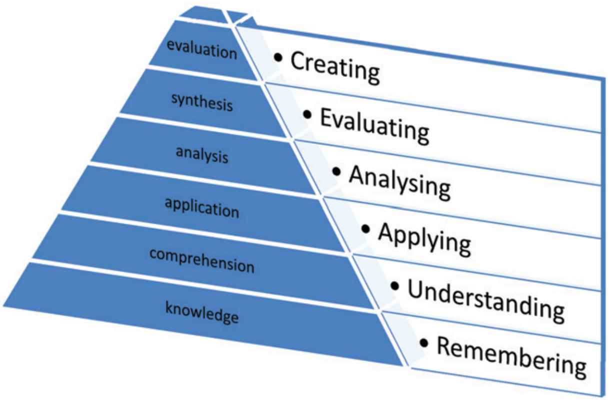

Figure 2. Bloom's taxonomy, after Atherton (2011).

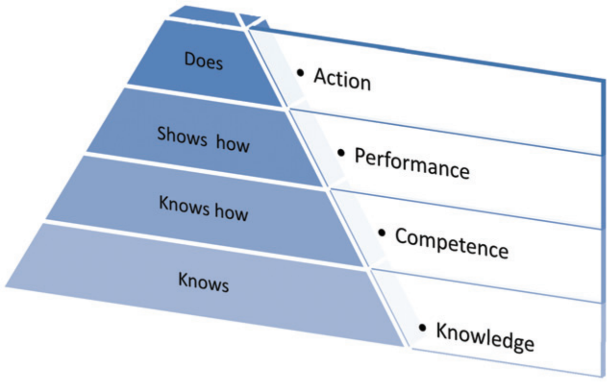

Figure 3. Miller's pyramid after Miller (1990).

(Miller, 1990; Figure 3), which can be used as a guide for planning and assessing within a curriculum. The pyramid is important, because in training students for the healthcare professions it is essential to remember that the outcome of training is intended to be a graduate who can take their place in the workforce (Action). Knowledge is the foundation of the pyramid – but not the pyramid itself.

Guided discovery learning and students' learning strategies

In a structured learning environment new knowledge is sufficiently similar to the existing knowledge to allow its relevance to be perceived. A more challenging condition applies in real life, when the relevance of information is often far from apparent. The variants of this situation are described by the Johari Window (Figure 4), named after its originators Joseph Luft and Harry Ingram in the 1950s (Luft & Ingham 1955).

Two things are immediately apparent from this construction – namely that discussion between individuals will increase the amount of practical knowledge, and that some things remain a mystery until we talk to someone else with a different range of knowledge or understanding. It follows that the more diverse a learning group's membership is, the more likely the individuals within the group are to learn. There will always be "unknown

	Known to self	Not known to self
Known to others	Known	Discovery through discussion
Not known to others	Discovery through discussion	"Unknown unknowns"

Figure 4. The Johari Window after Luft & Ingham (1955).

unknowns", but teachers can help students move into those areas through a careful choice of task, resources and, of course, patients. Before we look at the ways in which we can assist learning, there are two other considerations; both of which relate to the way that the learner thinks about knowledge.

Newble, Entwistle and their colleagues, in a number of studies (Newble & Clarke 1986; Newble & Entwistle 1986), have shown that there are several different learning styles, and that learners have different learning preferences. There is a real and active debate about whether learning styles are fixed or flexible, and the extent to which they are determined by the context (Coffield et al. 2004). It does seem clear that some learners prefer to work towards a deep understanding of what they are learning; others prefer to acquire the facts, a term known as surface learning. A moment's reflection will show that each can be an appropriate strategy. Sometimes deep understanding is needed, and sometimes it is enough to know "the facts" – the surface. It is important to know normal blood gas values or electrolyte levels and this surface learning triggers appropriate clinical action. However, to sort out a patient with acidosis requires a deeper understanding of how the various physiological systems interact. The ability to be strategic about the sort of learning we engage in is important. But it can be affected by the assessment system. So, if an assessment system tests for recall of facts, then the successful learner will employ surface learning. If the system rewards deep thought, understanding and reasoning, then the successful learner will aim for that. There is a difference of opinion about whether "strategic" is a third learning style or not (Newble & Entwistle 1986; Biggs et al. 2001). Recognising the different styles is important, as (most) lectures will appeal more to surface learners and extended project work will appeal more to deep learners. Some subject material actually needs to be known and rapidly recalled (blood gas values, electrolyte levels), while other material needs to be deeply understood to allow appropriate interventions (coping with acid base disturbances, or circulatory shock).

In a series of studies on American students in their college years, Perry (1999) noted that students change in their approach to learning as they progress through their college years. Typically students develop from an approach based on "duality", with a clear view that the teacher will tell them the difference between right and wrong, towards "multiplicity", where they recognise that context is important, and that they, their colleagues and the environment are valuable sources of knowledge and experience. Together with this change in focus comes a greater confidence with coping with uncertainty. This work was based on a relatively able, affluent and homogenous population of undergraduates and was subsequently extended by Perry's colleagues to a wider cross section of society. They (Belenky et al., 1997) uncovered a group of "silent" learners, who did not recognise their own rights to question or construct knowledge. Belenky and colleagues also extended the scale beyond receiving and understanding knowledge, to being co-constructors of knowledge (Belenky et al. 1997).

Some recent work by Maudsley (2005) shows that medical students develop in the way they learn, but that the progression is not always from duality to multiplicity. There are two explanations for this paradox, one is that the learners tend towards more strategic learning styles in order to cope with the demands of the assessment system; the alternative explanation is rather more complex and relates to the business of becoming a new member of the profession.

The process of learning new things is not just about acquiring knowledge (surface learning), it includes being able to make sense of it, and hopefully making use of it. But being able to do these things means that you have to acquire an understanding of where things fit. A novice stands at the threshold, not quite knowing what to expect, and sometimes not even knowing what they are supposed to be looking at. This is a state of liminality, and the learner needs to have some threshold concepts so that they can move further (Land et al. 2008; Meyer et al. 2010). Frequently the difficulty is in the vocabulary or the way that language is used (Bernstein 2000), but it can also be troublesome concepts (Meyer & Land 2006), or just becoming part of the "team" and assuming a new identity (Wenger 1998). The role of the teacher is to help the learner over the threshold, and, as discussed above, help them until it starts to make sense. If we follow Wenger's arguments (Wenger 1998) then we will see that the whole community has a role in leading the novice over the threshold, and helping them to take their place in the community of practice, that is, in this case, the healthcare profession.

How adults learn: a multi-theories model

It will be clear by now that there are several different theories about, and approaches to, learning. In the section that follows we introduce a model that encapsulates them and can be used to structure, plan and deliver successful learning experiences. We propose that there are five stages in the learning experience, which the learner needs to go through. The learner and the teacher will have particular responsibilities at each stage. We shall outline the model first, describe the responsibilities and then discuss each element in greater detail.

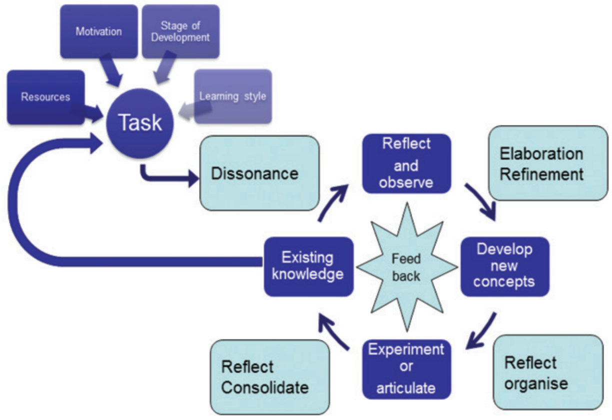

Figure 5. A proposed model of adult learning.

Outline

All learning starts with the learner's existing knowledge, which will be more or less sophisticated in any given domain (Figure 5).

The *dissonance* phase exists when the learner's existing knowledge is challenged and found to be incomplete. The challenge can be internal, when a learner is thinking things through, or it can be external, provided by a teacher or patient. There are several things that influence whether the learner will engage with the dissonance phase. These include the nature of the task, the available resources, the motivation of the learner, and the learner's stage of development and their preferred learning style. It ends with the learner reflecting and determining their personal learning outcomes.

During the *refinement* phase, the learner seeks out a number of possible explanations or solutions to a problem (elaboration), and through completing tasks, research, reflection and discussion refines the new information into a series of concepts which are, for the learner, new.

The *organisation* phase is where the learner develops or restructures their ideas to account for the increased information they have acquired. There are at least two elements to this: reflection in action, where the learner tests and re-tests hypotheses to makes sense of the information and the organisation of the information into schemata which (for the learner, at least) make sense.

The *feedback* phase is arguably the most crucial, as it is where the learner articulates their newly acquired knowledge and tests it against what their peers and teachers believe. The feedback will either reinforce their schema, or oblige the learner to reconsider it in the light of new information.

During the *consolidation* phase the learner reflects upon the process they have undergone, looking back over the learning cycle and identifying what they have learned from it, both in terms of increasing their knowledge base, but also in terms of the learning process itself (reflection on action).

Adult learning model in action

During each of these phases, we propose that there are specific roles for teachers and learners.

Phase	Learner's roles	Teacher's roles
Dissonance phase	• Identify prior (base-line) knowledge, skills and attitudes • Recognise what is unknown • Recognise personal development and learning needs • Participate in planning personal learning objectives and relevant experiences	• Provide the context in which the student can learn. • Increase extrinsic motivation through appropriate tasks • Help learner to recognise or promote internal motivation factors • Explore the learner's prior knowledge and experiences • Help student to identify his/her learning needs and the relevance of each
Refinement phase	• Think of many possible explanations or solutions to the case or problem. • Work out which are the most likely resources to refine the possibilities • Actively participate in the activity and experiences • Refine the information into a hypothesis	• Ensure the relevant learning experiences are available – at the appropriate level for the learner
Organisation phase	• Test and re-test the hypothesis • Organise the information into a "story" that makes sense to the learner	• Provide advance organisers for the learners – structures upon which they can continue to build. • Encourage reflection in action
Feedback phase	• Articulate the knowledge, skills or attitudes developed • Provide feedback to peers and staff • Accept, and if appropriate act upon feedback received from others	• Reflection on the learning experience (in action and on action) • Provide feedback to the learner, formally or informally. • Accept, and if appropriate act upon feedback received from the learner
Consolidation phase	• Reflection in the light of prior knowledge • Reflection on the learning process • Evaluate personal responsibility for the learning • Development of knowledge, skills and attitudes	• Provide opportunities for the learner to rehearse and/apply their new knowledge • Encourage reflection on action.

The model that we have given here shows that there are a number of ways in which applying the model can help in the design of learning activities, whether in one-to-one discussions, small group work, seminars or large lectures. The same principles apply to planning curricula, at short course, module or programme level. Whether working with an individual learner, or planning a major programme, the educator needs to recognise that the learner needs to move through a cycle, in order to truly understand and learn. We also need to be explicit that educator and learner have specific responsibilities at each stage of the learning process.

Adult learning model "expanded":

The dissonance phase. The key to success as an educator is probably providing the advance organisers. We need to know what we want the learner to learn, and how it fits into the greater scheme. That means that we must have clearly defined outcomes, at the appropriate levels of one of the modifications of Bloom's taxonomy (Figure 2). We may need a student to gain new knowledge, apply their knowledge or create a new hypothesis, for instance. Once we know our intended outcome we are in a position to start thinking about the best way of helping the learner to acquire, and demonstrate that they have acquired, the learning outcomes.

When we plan an educational intervention, we usually start with an idea of the task we want the students to be involved in (attend a lecture, take a history from a patient, write an essay, or whatever). There are, however, five considerations that define the most appropriate task, and they should come first.

Consider how the learner can be encouraged to articulate their prior knowledge. The entire learning process starts with what a learner already knows. In any intervention, we need to make sure that the learner has the possibility to articulate what they already know about something. There are many possible techniques, for instance "buzz groups" in lectures (Jaques 2003), the early phases of the PBL process where learners discuss what they already know (Taylor & Miflin 2008), or discussing something on the ward before performing an examination or obtaining a history from the patient. This stage helps the learner anchor the new knowledge in what they already understand, and places them on the first stage of the learning cycle. It also highlights to the learner where the gaps or uncertainties are in their knowledge.

Consider learning styles and their implications. If the aim of the educational intervention is simply to present the learner with new knowledge, then surface learning is the most appropriate learning style. It is not the most appropriate learning style, though, if the learner is required to understand, or later elaborate on the knowledge (Newble & Entwistle 1986; Biggs et al. 2001). Elaboration, and the later stages of Bloom's taxonomy require an increasing depth of understanding. There are complicating factors, since many learners are strategic in choosing surface learning styles before they enter University courses, so they may appear to show a preference for surface learning. Even at graduate level, if students know that they will be tested on their acquisition of facts, rather than their understanding, they will naturally choose a surface learning style. If the educator is aiming for a deeper level of understanding, then it will be necessary to make sure that the assessment process does not derail it.

It is possible, but challenging, to use lectures to provide more than surface knowledge. Deep learning comes through discussion, research and weighing up the evidence. Curricula that use PBL (Taylor & Miflin 2008), Team based learning (TBL: Michaelsen et al. 2002) and Case-based learning (Ferguson & Kreiter 2007) are designed with this in mind, but more traditional programmes can introduce elements of the more discursive styles, or require learners to complete particular tasks, such as research, small group work or preparing papers.

Consider the stage of development of the learner. In the same way that surface learning has attractions for many learners, Perry's stage of duality has attractions for both the learner and the educator (Perry 1999). Lectures can reinforce a state of duality in which the learner accepts what the lecturer says. But learners need to be comfortable with uncertainty, dealing with a partial picture and recognising when they need to know more. It is not enough for a doctor just to know the right answers in a perfect situation; we rightly expect them to understand why they are the right answers, and how they are determined by circumstances. A senior clinician will have sufficient experience to recognise this, and it should come across in traditional bedside teaching. Learners can also develop their understanding of systems through well-facilitated PBL or case-based learning, where the facilitator encourages learners to think about the value they attribute to "facts", and the way in which they think about them. Helping the learner shift from duality to early multiplicity, and look beyond the obvious first impressions, is crucial to bedside teaching, for instance, where test results or images have to be related to the patient's account of their problem.

Consider the learner's motivation. Sobral's (2004) work has shown that student's motivation can be strongly influenced by the educational environment and their frame of mind towards learning. This is also central to the self-determination theory (ten Cate et al. 2011; Kusurkar & ten Cate 2013). If that is the case, then early clinical contact that is both stimulating and relevant to the desired learning outcomes will be beneficial.

Although adult learners are expected to be self-motivated, they will also have a host of competing concerns. Balancing two or more imperatives is a normal state of affairs for both learner and educator. It is the responsibility of the educator to ensure that the task will engage the learner for long enough to allow the learner's enthusiasm to be captured. It is equally important not to squander the learner's energy and enthusiasm with poorly thought out tasks, or issues that are either trivial or too difficult.

There is more to consider here, particularly the dimensions of self-directed learning (Garrison 1997), which include motivation and self-regulation (Zimmerman 2002). There is some evidence that problem-based learning students are better at self-regulation (Sungur & Tekkaya 2006), which includes the ability to construct meaning. The goal, however is self-directed learning which transcends self-regulated learning to include motivation and, crucially, the ability to determine what should be learned (Loyens et al. 2008). Again, this is fostered by problem-based learning, but is easily destroyed by publishing or giving the students detailed intended learning outcomes.

Consider the resources. Naturally, we need to consider physical resources such as space, books, journals, and access to electronic resources. The most precious resource, for all of us, is time. Whenever an educational activity is planned there must be sufficient time devoted to preparation and planning, including planning the way in which the activity will be evaluated and assessed. Clearly there will need to be sufficient time made clear for the educator/s involved in the delivery, but also in the evaluation and assessment processes. It is also important that there is sufficient time for the learners to engage with the learning activity and complete any necessary additional work, such as reading, and of course reflecting upon the material and the way in which they have learned.

Finally consider the task. The task the learners are set has to take into account all of the preceding considerations.

It needs to have learning outcomes which are aligned with the curriculum as a whole and which are specific enough to be reasonably achievable within the allocated time. No one could learn the anatomy and physiology of the nervous system in a couple of days, but they might be able to master the anatomy and physiology that underlie the crossed extensor reflex.

Opinions are divided about whether every task should be assessed, but it is widely asserted that "assessment drives learning" (Miller 1990), so attention needs to be paid to the assessment opportunities, and the material covered should be included in the assessment blueprint (Hamdy 2006).

The elaborate and refine phase

The dissonance provided by the task has been sufficient to introduce new possibilities, facts and concepts to the learner. They must now start to make sense of them. The first stage in this process is to consider as many of the possible explanations for the new information as possible. This is equivalent to the brainstorming phase in problem-based learning and has two main advantages. The first is that it helps ensure that connections are made between the new information and previous knowledge, ensuring that everything is learnt in the context of what is already known. The second is that it reinforces our natural tendency to be appropriately inventive and to think widely. This skill will be crucial for the future healthcare professional, where the obvious explanation for a patient's symptoms may be wrong. Shortness of breath, for instance, may have a respiratory or a cardiovascular origin.

Elaboration without refinement will just lead to confusion, so once a number of possible explanations for a scenario have been determined, it is necessary to refine them into the most plausible solutions. This will be after some research, reflection and discussion or in the clinical environment after reading the patients notes or seeing the results of appropriate tests. In this phase we are mirroring the scientific and clinical method, which is a valuable exercise in and of itself. The outcome of this phase is the generation of a working hypothesis.

Most of what happens in the elaboration and refinement phase is internal to the learner, but the success of the venture will stem from the nature of the task they were set, and the provision of appropriate resources. The task must be such that it requires some thought and engagement to complete it, and the resources need to be appropriate to the task and the understanding of the learner. This phase is the key part of problem-based learning, but can also arise out of clinical and bedside teaching when the educator is aware of the possibilities and careful to exploit them.

The organisation phase

During this phase the learner looks at a problem from all angles, testing and retesting the hypothesis against what they already know. Part of this phase is fitting the information into what the learner already knows, and part of it is in constructing the new information into a story that makes sense to the learner. This is a complex task and involves the learner reflecting in action, challenging him- or herself to reflect critically.

The educator has two roles in supporting the learner. The first role is to provide them with scaffolding, a skeleton to support their ideas and give them coherence and structure. This may be the framework of the programme, with a series of themes, or it might be a lecture or lecture series, or it could even be a syllabus. The danger with scaffolding is that if it is too detailed it removes any freedom or responsibility from at the learner. It then becomes very difficult to determine whether true understanding (rather than simple recall) has been achieved. It also means that the learner will not know, until too late, whether they truly understand the subject.

The second role for the educator is to encourage critical reflection. At its best the educator will model this in tutorials or the supervising clinician in bedside teaching, but it is perfectly possible to model one's way of thinking about a problem in a lecture or seminar. Given that so much of our knowledge base changes, critical thinking is probably the most important skill we can give our students.

It is essential that we provide students with opportunities to test their reflective skills. There are many possible ways but they include discussion with each other, informally, or in small groups, with the educator, or with critical friends. Although the idea of critical friends (Baskerville & Goldblatt 2009) is usually associated with teachers/researchers, there is no reason why it would not work between students, although they would need training and support in the first instance.

Feedback

There are two elements to feedback. The first is articulating what has been learned. All educators know that the real test of understanding something is explaining it to other learners. So the newly acquired material needs to be explained, or used in some way.

The educator's role, together with other learners, is the second element of feedback, which is to point out the strengths and weaknesses of any argument, and to ask further questions, until learner and educator are satisfied that the outcome has been met. In any facilitated small group session or bedside teaching session, this is part of the role of the facilitator – it is perfectly possible and acceptable to challenge constructively without handing out the correct answer or humiliating the student. In a group that is working well (whether a formal, structured group or a self-formed study group) other group members will pose questions and seek clarification. This is a combination of feedback and discussion, and can lead to co-construction of knowledge (Belenky et al. 1997). It is also relatively simple to provide feedback in a lecture theatre – either through team-based learning activities, or through instant feedback devices such as "clickers", or, dare one say, the raising of hands!

Although feedback is best given in frequent, small, doses, there are clearly times when it is crucial. The most obvious example is when the learner is being assessed. This is when learners realise the extent to which they have acquired and can demonstrate new knowledge. Any effective assessment system will provide learners with an indication of where they are going wrong, and which areas they should focus on for clarification of their understanding.

There are two further elements of the feedback phase that are often ignored. The first is the duty of the educator to seek and reflect upon the feedback they obtain about their own performance. In this way we can develop and hone our skills to become better at what we do. The second relates to epistemology. Educator and learner also need to reflect upon the way that they have been learning, and the relative highs and lows of the experience. This is to ensure that we can work smarter (rather than harder) next time.

The consolidation phase

The learner faces two challenges in this phase. The first is to reflect on what has been learned in the light of what was known before. Does it all make some sort of sense, or is there a logical inconsistency that needs to be thought through? How does the new knowledge help to explain the bigger picture and increase our understanding?

If the exercise has been subject to assessment, this is where the learner should ideally think about their assessment results, and their areas of relative strength and weakness, so as to ascribe confidence levels to what they think they know.

The learner will already have articulated (in the previous phase) how they felt the learning process worked. In this consolidation phase they need to consider the extent to which they took personal responsibility for their learning. How far are they along the continuum towards co-constructing knowledge? To what extent were they personally responsible for any breakdown in the process? What should they do differently next time?

The role of the educator in this phase is to provide encouragement for reflection on action. This might be through the provision of written feedback about examinations, highlighting areas of relative strength and weakness, or it could be through an appraisal or portfolio process. The key is to move from a right/wrong type of feedback to one where the possibilities for future development are made explicit. The educator's role, after all, is to lead the learner towards a deeper understanding.

Institutional implications and applications of adult learning theory in medical education

At an institutional level connecting adult learning theory with practice is challenging. Some theories or aspects of a theory will be more relevant and helpful than others in a particular context. In exactly the same way that clinicians are expected to adopt practices on the basis of the best available evidence, educators should make use of the best available evidence to guide their educational decisions. Medical education institutions should rationalise and be explicit about their mission, vision, programme and curricula development, learning strategies, students' assessment and programme evaluation guided by adult education theories and their particular socio-cultural context.

Institutional mission, vision and curriculum outcome

Many health care education programmes will have mission or vision statements describing graduates who have knowledge, skills and attitudes that allow them to respond to the health needs of the population with a high degree of moral and social responsibility. In outcome-based education one can expect a variety of strategies, each relying on one or more different educational theories. Understanding how people learn is important, and both learners and educators need to remember that learning is a process through which they weigh their knowledge against a critical examination of alternative possibilities (Ahlquist 1992). This understanding is basic to problem-based learning and the majority of clinical practice.

Although knowledge is the easiest, and most public domain, more than half of the outcome domains of medical education are related to attitude e.g. lifelong learning, empathy, utilitarianism, communication with patient and colleagues, ethics and professionalism. Transformative and experiential learning theories constitute an important theoretical frame for learning strategies suitable for these outcomes. The institution should be ready to embark on educational and cultural environment changes in order to operationalise these concepts.

Learning and teaching

Applying adult learning principles in medical education will probably necessitate changing educators' and learners' perceptions of their roles. Adult educators may consider adopting a view of themselves as both learners and educators. The learner's role is not only to receive knowledge but also to search, challenge, construct knowledge and change their own perception, views and beliefs.

Applications of these strategies necessitate significant institutional culture changes, active faculty development and increased learner autonomy and self-direction. To develop these skills all learners (including faculty members) should be trained to ask questions, critically appraise new information, identify their learning needs and gaps in their knowledge and most importantly to reflect and express their views on their learning process and outcomes.

The clinical environment is challenging for the learner and the educator. Clinical educators, students and patients interact together within the context of a hospital, clinics and community at large not just in a classroom. Time is at a premium, and the stakes for the patient are often high. Because of this it is important to make the best use of learning theories when helping people to learn.

Self-directed and experiential learning are key strategies, but feedback is crucial to help the learner make the best use of their contact time. Clinical reasoning, hypothesis generation and testing are essential skills for good clinical practice. The model of adult learning we have illustrated (Figure 5) shows that perception, insight, meaning-making and mental networking are interlinked and essential for good reasoning abilities. The clinical teachers should explain how they come up with a diagnosis or take a management decision by exploring with the learner the mental processes in the teacher's and the learner's minds by which "the implicit becomes explicit".

Self-directed learning and student goal-setting should always be encouraged and supported but they should also be discussed, monitored and recorded. Portfolios, logbooks and reflective journals are particularly important tools for this. The key for successful implementation is for them to be more than "tick box" exercises, and we have found that using them as a basis for discussion makes them more effective.

Ethics and professional behaviours can be, and often are, taught but understanding them is demonstrated and consolidated within the clinical environment. Asking students to observe, record and discuss incidents that have ethical and professional implications is crucial to this development (Maudsley & Taylor 2009). Perspective transformation theory (Mezirow 1978) is most appropriate for acquiring these competencies. It supports reflection, and examination of the learner and teachers' assumptions and beliefs, hoping it may lead to individual and social change. An off-shoot of adult learning theories is situated cognition (Wilson 1993) developed by Wenger (1998) into the theories of communities of practice. Its application to the clinical environment is relevant. Learning and thinking are social activities structured and influenced by the setting and tools available in a specific situation (Lave & Wenger 1991). Learning and teaching approaches at the bedside are different from the operating room, emergency department or in the community (Durning & Artino 2011; Yardley et al. 2012). Each context has its educational power and value. Observing the performance and behaviour of a trainer as role model, reflection in and on action and feedback on performance are important education principles to be considered in teaching and learning in clinical settings.

Student assessment and programme evaluation

Awareness of adult learning theories is needed to develop and select evaluation systems and instruments that can measure the expected competencies and outcomes. What to measure, how, when, by whom are important key questions and their answers are not always easy. The assessment should be tied to specific learning outcomes, and the learner should be given whatever feedback will help them develop or consolidate their knowledge, skills or attitudes. Time constraints mean that some elements of the feedback will need to be the learner's self- and peer-evaluation, but this should not be seen as a problem. Encouraging discussion, debate and reflection will increase learning opportunities. It is important to allow time, and provide a structure, for these activities if they are to be properly integrated into the learning/assessment system.

As mentioned above, a well thought through portfolio/log book with elements of reflection will allow for the learner's progress to be documented for themselves, and, importantly, for the educator/assessor.

By applying adult learning theories consistently and carefully, the educator can be sure of helping learners become part of the healthcare profession, and lay the foundations for a career of life-long development.

Summary

(1) Adult learning theories are related to several educational, social, philosophical and psychological theories. Most accessibly these were clustered by Knowles and called "andragogy" clarifying how adults learn best and their attitude towards learning.

(2) A simple model is proposed which has considered different aspects of adult learning theories and their implication to the learner's role and teacher's role. Although the model is presented as a cycle actually the learner and teacher can enter the cycle at any point.

(3) Adult learning theories should influence all aspects of health profession education, from mission and vision statements, outcomes, implementation and evaluation.

(4) The clinical teaching and learning environment is an ideal field for using adult learning theories and demonstrating their utility. Reinforcing clear thinking in both teacher and learner and considering them should improve clinical learning, and even clinical outcomes.

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A critical review of simulation-based mastery learning with translational outcomes

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OBJECTIVES This article has two objectives. Firstly, we critically review simulation-based mastery learning (SBML) research in medical education, evaluate its implementation and immediate results, and document measured downstream translational outcomes in terms of improved patient care practices, better patient outcomes and collateral effects. Secondly, we briefly address implementation science and its importance in the dissemination of innovations in medical education and health care.

METHODS This is a qualitative synthesis of SBML with translational (T) science research reports spanning a period of 7 years (2006–2013). We use the 'critical review' approach proposed by Norman and Eva to synthesise findings from 23 medical education studies that employ the mastery learning model and measure downstream translational outcomes.

RESULTS Research in SBML in medical education has addressed a range of interpersonal and technical skills. Measured outcomes have been achieved in educational laboratories (T1), and as improved patient care practices (T2), patient outcomes (T3) and collateral effects (T4).

CONCLUSIONS Simulation-based mastery learning in medical education can produce downstream results. Such results derive from integrated education and health services research programmes that are thematic, sustained and cumulative. The new discipline of implementation science holds promise to explain why medical education innovations are adopted slowly and how to accelerate innovation dissemination.

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INTRODUCTION

This article presents a critical review of simulation-based medical education research reports that use the mastery learning model to achieve translational outcomes. The goal is to demonstrate that medical education interventions embodied in simulation-based mastery learning (SBML) can produce measureable improvements in patient care practices, patient outcomes and patient safety.

Simulation-based education

Simulation-based medical education (SBME) involves 'devices, trained persons, lifelike virtual environments, and contrived social situations that mimic problems, events, or conditions that arise in professional encounters'.[1] The use of simulation in medical education has been traced to early 18th century France[2] and to other European doctors in the 19th century.[3] Medical simulations range widely in fidelity and realism from simple task trainers to manikins, multimedia computer systems[4] and standardised patients.[5] Simulations allow medical learners to practise clinical skills under safe, controlled, forgiving conditions, undergo formative assessment, and receive focused feedback with the goals of acquiring and maintaining clinical competence. Anaesthesiologist David Gaba argues: 'Simulation is a technique – not a technology – to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner.'[6]

Medical education research spanning at least four decades demonstrates that simulation technology, used under the right conditions (e.g. curriculum integration, deliberate practice, rigorous measurement, feedback, faculty staff preparation, organisational support) can have large and sustained effects on knowledge and skill acquisition and maintenance among medical learners. These outcomes have been documented in a series of review articles that use varied approaches to research synthesis, including narrative,[4] systematic with qualitative data synthesis,[1] critical-realist[7] and systematic with quantitative data synthesis (meta-analysis)[8,9] methods. Despite their methodological differences, these reviews all conclude that SBME is highly effective, especially in comparison with no-treatment (placebo) conditions[8] and traditional clinical education.[9] This scholarship has also revealed a dose–response relationship between the intensity of SBME interventions and learning outcomes.[7]

Mastery learning

Mastery learning has its origins in educational engineering. The key question is: How shall we design an educational environment that produces maximum learning outcomes among all trainees? The answer is to create and implement a set of educational conditions, a curriculum and assessment plan that yield high achievement among all learners.

Mastery learning in medical education is a stringent form of competency-based education.[10] It originates from early research in elementary, secondary and higher education dating from the early 1960s,[11–17] and once expressed as a mathematical model.[18] As stated elsewhere,[19,20] mastery learning has at least seven complementary features: (i) baseline or diagnostic assessment; (ii) clear learning objectives, sequenced as units in increasing difficulty; (iii) engagement in powerful and sustained educational activities (e.g. deliberate skills practice, data interpretation, reading) focused on reaching the objectives[21,22]; (iv) a fixed minimum passing standard (e.g. test score, checklist percentage) for each educational unit; (v) formative assessment with specific feedback to gauge unit completion at the minimum passing standard for mastery; (vi) advancement to the next educational unit given measured achievement at or above the mastery standard (summative assessment), and (vii) continued practice or study on an educational unit until the mastery standard is reached.

The goal in mastery learning is to ensure that all learners accomplish all educational objectives with little or no variation in outcome. The amount of time needed to reach mastery standards for a unit's educational objectives varies among learners.[19,20]

Most research to study the outcomes of the mastery learning model has been conducted in the settings of elementary and secondary education.[23,24] Results from rigorous research involving schoolchildren consistently show 'extremely positive student learning outcomes'.[23] Such work has been extended into higher education studies in which a moderate effect size has been achieved for mastery learning knowledge interventions compared with traditional classroom instruction.[25] Cook and colleagues recently published a systematic review and meta-analysis of mastery learning for health professionals using technology-enhanced simulation compared with any intervention or no intervention.[26] Results from this review show that 'mastery SBME was associated with large effects on skills (41 studies; effect size [ES] 1.29 [95% confidence interval, 1.08–1.50]) and

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moderate effects on patient outcomes (11 studies; ES 0.73 [95% CI, 0.36–1.10]).'[26]

Translational outcomes

Translational outcomes are educational effects measured at increasingly distal levels beginning in a classroom or medical simulation laboratory (T1) and moving downstream to improved and safer patient care practices (T2), better patient outcomes (T3)[27–30] and collateral educational effects (T4) such as cost savings, skill retention, and systemic educational and patient care improvements.[31,32] Similar ideas about translational outcomes have been expressed by Kalet *et al.*,[33] who describe educationally sensitive patient outcomes, such as patient activation and clinical microsystem activation, as key goals of medical education.

This article has two objectives. Firstly, it aims to critically review SBML research in medical education, evaluate its implementation and immediate results, and document measured downstream translational outcomes. Secondly, it aims to address implementation science, scholarship that aims to break down barriers to efficient and effective medical education and the provision of health care. The theme throughout the article is that continued reliance on historical methods of clinical medical education should be reduced and augmented by rigorous, evidence-based, mastery learning practices.[34] We conclude with a coda that addresses recent Accreditation Council for Graduate Medical Education (ACGME) policy statements about competency-based education, professional education milestones, and outcome assessment.

METHODS

This is a qualitative synthesis of mastery learning translational science (TS) research. The study addresses a focused question: What is the evidence that SBML outcomes achieved in the educational laboratory (T1) transfer to downstream patient care (T2), patient improvement (T3) and collateral (T4) outcomes? We critically review selected research reports that employ the mastery learning model in medical education and measure immediate and downstream translational outcomes. The review is deliberately selective and critical, rather than exhaustive. It relies on Norman and Eva's 'critical review' approach to literature synthesis[35,36] combined with the 'realist review' approach advanced by Pawson and colleagues.[37] Eva argues: 'A good educational research literature review… is one that presents a critical synthesis of a variety of literatures, identifies knowledge that is well established, highlights gaps in understanding, and provides some guidance regarding what remains to be understood. The result should give a new perspective of an old problem… The author… should feel bound by a moral code to try to represent the literature (and the various perspectives therein) fairly, but need not adopt a guise of absolute systematicity.'[36] Pawson *et al.*[37] agree by stating: '…the review question must be carefully articulated so as to prioritise which aspects of which interventions will be examined.'

The critical-realist approach to integrative scholarship[38] begins by defining the scope of the review, identifies a focused question and sets a clear purpose. Search terms are defined and a sampling strategy is formulated using a theory-based framework. However, unlike a systematic review (with or without meta-analysis), the intent of a critical-realist review is to collect, integrate and interpret results from the most compelling studies that satisfy the search terms and strategy. The search and written presentation need not be exhaustive. A critical-realist review judges the relevance and rigor of available research studies in terms of the theoretical framework. The goal is to summarise findings from different studies qualitatively, and to seek confirmatory and contradictory findings. A critical-realist review also attends to the contexts in which research studies reside in order to elucidate and explain what makes educational interventions work in a way that numbers alone cannot capture.[35–37]

We searched multiple databases (MEDLINE, EMBASE, PsycINFO, Web of Science) and also examined reference lists of widely cited papers and review articles from December 2012 to January 2013. Search terms included 'simulation-based education', 'simulation training in health care', 'mastery learning' and 'simulation-based mastery learning'. This approach yielded 3514 articles published between 1968 and 2013. Two reviewers independently reviewed the titles and abstracts of all retrieved articles. Articles were excluded if they were not written in English, did not involve education in the health professions, or did not use a form of simulation (including standardised patients, task trainers and full-body human patient simulators). Mastery learning was defined as an educational programme featuring all of the seven steps listed above. Interventions that did not include a step (e.g. absence of baseline testing, deliberate practice or formal summative assessment) were excluded for failing to meet the definition of mastery learning. The full texts of articles that were not excluded based on abstracts (n = 66) were read by two reviewers. All disagreements were resolved by consensus. We identified 23 articles on SBML published from 2006 to 2013 that measured outcomes at least on the T1 level.

Several studies that did not explicitly state the term 'mastery learning' in the title or text were included. In these cases, descriptions of the type, intensity and quality of the educational intervention (e.g. 'demonstrating all critical steps flawlessly') as part of a comprehensive educational intervention were synonymous with the mastery learning model.

RESULTS

The mastery model has been used in medical education skill acquisition studies for a variety of clinical skills. Table S1 (online) summarises a selective review of research studies that employ the mastery learning model and also measure downstream TS outcomes.

The clinical skills addressed in these mastery learning studies range from interpersonal to technical and procedural skills, which account for a majority of the learning outcomes. The skills include management of intensive care unit (ICU) patients on ventilators,[39] and a variety of invasive and non-invasive medical procedures including thoracentesis,[40] lumbar puncture,[41,42] communicating with a chronically ill patient about goals of care (code status discussion),[39] cardiac auscultation,[43] advanced cardiac life support,[44–46] temporary haemodialysis catheter insertion,[47,48] paracentesis,[49,50] laparoscopic surgery[51–54] and central venous catheter insertion.[31,32,55–59] Table S1 also shows that mastery learning medical education outcomes have been measured at all four TS levels. Specific examples include improved procedural and communication skills measured in a simulated setting (T1),[39–41,44,47,49,51,52,55] and at the bedside (T2).[39,42,43,45,46,53,55,56] Several studies report the impact of SBML on patient outcomes that relate to a reduction in complications, and refer to a reduced hospital length of stay, fewer blood transfusions and fewer ICU admissions,[50] improved quality of surgical care,[54] and reduced catheter-associated bloodstream infections (T3).[57] Collateral effects (T4) are demonstrated by reduced health care costs[31] and impact on other trainees in the learning environment.[32] Finally, several studies show that SBML outcomes are largely robust to decay but may require booster training at set time intervals.[46,48,58,59]

An illustrative example of SBML in medical education is seen in a recent study by Barsuk *et al.*[41] that compared the acquisition of lumbar puncture (LP) skills in postgraduate year (PGY) 1 internal medicine (IM) residents' in a mastery learning curriculum with that of PGY-2, -3 and -4 neurology residents using traditional clinical education. Figure 1 shows that IM residents expressed wide variation in LP skills at baseline pre-testing using an LP simulator. However, after a minimum 3-hour education session featuring deliberate practice[21] and feedback, all IM residents met or surpassed a mastery standard for LP skills at post-test. By contrast, only two of the 36 (6%) traditionally trained PGY-2, -3 and -4 neurology residents from multiple training programmes met the passing standard using the LP simulator, although they had much more clinical experience in LP. The investigators also report that 42% of the traditionally trained neurology residents did not even specify routine laboratory tests for cerebrospinal fluid after the specimen was obtained. The research report concludes: 'Few [traditionally trained] neurology residents were competent to perform a simulated LP despite clinical experience with the procedure.'[41] An editorial that accompanied the publication of the LP research comments: 'The Barsuk *et al.* study is clearly a wake-up call for all of us who were trained in the era of "see one, do one, teach one" – the so-called "apprenticeship" model of clinical training. The old training methods are no longer enough to ensure the best education, and thus the best care for patients.'[60]

DISCUSSION

This critical review shows that SBML is a powerful educational model that improves clinical skills and has important downstream effects on health and society. This review also illustrates an important point about the documenting of TS outcomes from health professions education research. Translational science education outcomes cannot be achieved from single, isolated studies. Instead, TS results in medical education derive from integrated education and health services research programmes that are thematic, sustained and cumulative, as in the series of studies on central venous catheter insertion that produced results from T1 to T4 levels.[31,32,55–59] Such translational education research programmes must be carefully designed and executed to capture and reliably measure downstream results.[28,29] Use of

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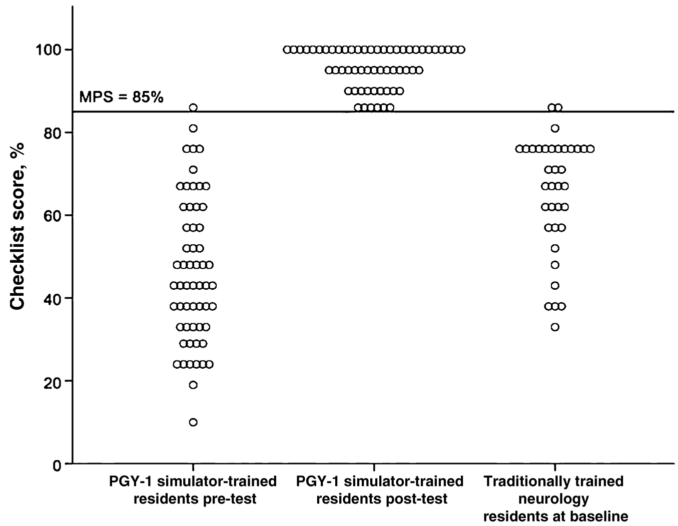

Figure 1 Clinical skills examination (checklist) pre- and final post-test performance of 58 simulator-trained first-year internal medicine residents and baseline performance of 36 traditionally trained neurology residents. Three internal medicine residents failed to meet the minimum passing score (MPS) at initial post-testing. PGY = postgraduate year. (From Barsuk *et al.*[41] Reprinted with permission of Wolters Kluwer Health)

the mastery model is one way for medical educators to contribute to today's rapidly changing health care environment. The studies reviewed here clearly show that SBML education research can improve health for individuals and populations. Ensuring a well-trained and competent workforce is likely to have additional far-ranging benefits, including better patient care practices and improved patient outcomes, that require further study.[29]

The findings of this selective, critical review of SBML present more details about the designs, measures, outcomes and translational qualities of its constituent studies than earlier systematic reviews of patient outcomes in SBME.[26,61] These two approaches to integrative scholarship are complementary but not identical. Variation in the definitions of search terms and the inclusion and exclusion criteria used to identify eligible studies is responsible for differences in the number and interpretation of research reports included in these reviews. Greater uniformity is likely to be achieved as terminology becomes standardised.

Mastery learning programmes in medical education do not occur in a vacuum. They operate successfully in a professional context that has personnel, material and institutional resources that advance the mastery learning agenda. An effective programme in one setting may not transfer to another organisation. Dissemination of innovations like SBML in health care is very difficult and is shaped by 'perceptions of the innovation, characteristics of the individuals who may adopt the change, and contextual and managerial factors within the organisation'.[62]

Implementation science addresses the mechanisms of education and health care delivery.[63,64] The aim of implementation science is to '[study] and seek to overcome health-care organisational silos and barriers, pockets of cultural inertia, professional hierarchies, and financial disincentives that reduce health-care efficiency and effectiveness'.[29] The slow adoption of mastery learning in medical education is a case study of implementation science. The intellectual foundation of mastery learning was established in 1963,[11] 5 decades ago, and subsequent incarnations within and outside medical education have occurred up to the present.[10,12–17] The educational and health care advantages of mastery learning are unequivocal.[19,20,28,29] However, educational inertia grounded in Osler's *natural method of teaching*, now known as the 'apprenticeship model' of clinical education, is a key reason why mastery learning is not yet prominent in medical education.[34] We encourage widespread adoption of the mastery learning model in medical education emphasising 'excellence for all' as habitual methods of clinical education are augmented by evidence-based competency approaches.

What will it take for health science education programmes to implement the mastery learning model to achieve TS goals? Table 1 identifies components of an SBME translational research programme that incorporates mastery learning derived from an earlier report.[29] The components include: (i) health professions learners; (ii) educational resources; (iii) human resources, and (iv) institutional support. Table 1 identifies evidence in support of mastery learning programmes that is well established and points out gaps in understanding that warrant research attention. These gaps refer to the utility of SBML for acquiring team-based competencies, the attributes of skilful SBML instructors, the leadership needed to support SBML programmes, and many other issues. Medical educators who intend to adopt the mastery learning model in a local context should attend to these and other variables – institutional culture, history, inertia – as the programme is introduced.

This review is subject to several limitations that derive from the lack of reliable research data and that warrant attention as the field of SBML advances in medical education and becomes more refined.

The current review shows that SBML holds promise for fulfilling the goal of achieving TS outcomes, but does not yet provide definitive, airtight answers. Few medical mastery learning studies have achieved downstream results at the T2 (better patient care practices) and T3 (better patient outcomes) levels. Table S1 reveals that several research groups have reported T2 and T3 results for paediatric LP,[42] cardiac auscultation,[43] advanced cardiovascular life support,[45,46] temporary haemodialysis catheter insertion,[48] paracentesis,[50] laparoscopic surgery[53,54] and central venous catheter cannulation,[55–57] but much more research is needed. Translational T2 and T3 results are more likely to be achieved through educational and health services research programmes that are thematic, sustained and cumulative rather than in single, one-shot studies. Translational T4 outcomes (e.g. cost-effectiveness, collateral results) can be achieved when researchers design studies and measure outcomes that transcend educational and clinical variables and are alert to unintended research outcomes.

Translational educational outcomes have also been achieved by a medical education research programme that approximates SBML but does not report all mastery features explicitly (e.g. baseline assessment, minimum passing standard). An obstetric education research group in the UK has reported statistically and clinically significant reductions in infant birth complications (i.e. brachial palsy injury) caused by shoulder dystocia and neonatal brain injury from lack of oxygen during birth as a consequence of simulation-based training of individuals and teams.[65–67] These are all T3 outcomes. Research to identify the features of this educational intervention that produce good clinical outcomes among patients and to establish whether the features conform with the SBML model is required.

Education and health services research programmes that employ SBML and technology-enhanced simulation,[8,26] and that aim to achieve clinical outcomes in the health of individual patients or the wider public[26,33,61] must be crafted carefully, be rigorous and attend to such details as the unit of analysis (i.e. the learner or patient) issue in original health care research.[61] Quantitative and qualitative research programmes are needed not only to demonstrate that innovations like SBML produce intended results, but also to show how and why the results are achieved in different settings.[68]

The selection or creation of measures that yield reliable data that permit valid decisions to be made about the effects of educational interventions represents a persistent issue in medical education research. Most of the studies covered in this review used observational checklists as principal outcome measures and produced data with acceptable reliabilities. Although many of the checklists have a procedural focus, they also include items that involve communication skills (e.g. obtaining patient consent, verifying orders with health care team members), team leadership, ordering and interpreting laboratory tests, calculating and adjusting ventilator settings, attending to patient and family emotions, and many other cognitive, social and affective variables. On the horizon, haptic measures hold promise to provide reliable data that can be used to reach valid decisions about key health care variables.[69] The delivery of quality health care is very complex on technical, affective, social and professional grounds. The development of educational programmes and outcome measures that capture this richness is a constant challenge in medical education research.

Simulation-based mastery learning is beginning to produce strong and lasting educational effects when it is implemented, managed and evaluated with thought and rigor. We believe the mastery model, with or without simulation technology, holds great promise to help medical learners to acquire and maintain a broad array of technical, professional and interpersonal skills and competencies. Continued research is needed to endorse or refute this assertion.

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Table 1 Components of a simulation-based mastery learning translational education and research programme that incorporates mastery learning

Component	Evidence that is well established (examples)	Gaps in understanding What remains to be understood
Learners		
Health professionals in training: individuals and teams	The mastery model works with individual performance for individual tasks[40] and individual performance within teams[44]	Does the mastery learning model work for team-based competencies and can these have translational outcomes? Derive team-based metrics and mastery standards that are translatable to the clinical environment
Highly motivated	Learners who volunteer and consent for a study can significantly improve their skills and mastery outcomes[41]	What motivates learners: extrinsic versus intrinsic variables? Does participation in a study select high achievers? Do the role(s) of the study investigators or faculty staff affect motivation? Does evaluation apprehension impact performance? What is the motivation for faculty staff to educate learners to a mastery level?
Educational resources		
Training materials appropriate to learning objectives	There is a clear description of learning resources used in the study, such as rigorous measures that yield reliable data[55]	Are the outcomes dependent upon specific institutionally developed resources? Are these resources available with reasonable options for other institutions?
Trained faculty staff	The report states that faculty staff are trained and experienced in teaching with simulation[49]	What are the explicit experiences and skill set that make simulation instructors, not just those participating in a study who have additional motivation to succeed, effective? What are criteria that can generalise to other institutions?
Space	Education and evaluation are carried out in a protected location: skills centre or in situ[43]	What is the minimum and maximum space required? Does the learning environment need to be separate from the clinical environment? Separation is often facilitated during effectiveness studies, but is this true in general?
Training time	What is the average training time required for a skill set? What is the range across skill sets? How was the training time scheduled?[41]	How is training time negotiated? Is there explicit involvement with training programme leadership?
Educational funding to support the issues above	Funding support protects time for faculty, space and resources[45,46]	What are the ongoing costs of building and sustaining a mastery training programme? Beyond the one-time start-up capital costs, what is the cost of training learners to a mastery level? What is the evidence that mastery learning studies with funding are better rated?
Institutional senior leadership support	External leadership support for the programme increases the likelihood of success[57]	What is the minimum leadership support that is needed: curricular institutionalisation, funding support, faculty recognition and reward? Are there extrinsic drivers for the institution (e.g. accreditation, patient safety)?

Table 1 (Continued)

Component	Evidence that is well established (examples)	Gaps in understanding What remains to be understood
Human resources		
Scientist-leaders and staff	Functionally diverse research teams are more effective than homogeneous teams[75–77]	Is there an optimal formula for research team composition?
Institutional support		
Value and reinforce T1 SBME outcomes in situ	Institutional leadership supports and advances the goal of translational outcomes[56,57]	What are the critical components for an institution to adopt a translational outcomes training programme?
Advance science of health care delivery and patient safety	Institutional leadership sets an agenda for the advancement or improvement of health care quality outcomes and improved patient safety[56,57]	Can translational outcomes be achieved without full institutional support and culture change? What is the minimum level of change required to reach a 'tipping point'?
Patient records that contain reliable data	There is an explicit description of the electronic health care record (or paper) and how it was accessed to retrieve reliable data to evaluate translational outcomes[49]	What are the resources required (patient records) and what expertise is required to access them and to mine reliable and meaningful patient outcomes that are relevant to the training programme?

Coda

The ACGME[70] and medical education scholars[71] have called for new approaches to clinical education and an assessment-based focus on professional competencies, educational milestones and high achievement standards. This means that undergraduate clerkship directors, postgraduate residency and fellowship programme directors, and directors of continuing medical education programmes must rethink and reorganise educational offerings to remove passive clinical experiences and install rigorous educational practices. Simulation-based mastery learning coupled with rigorous formative and summative educational evaluation is an implicit feature of these arguments.[72] Medical educators across the continuum, from the directors of undergraduate basic science courses and clinical clerkships, to the directors of postgraduate residency programmes, medical school curriculum committees and academic deans, should endorse SBML as a new paradigm.

The fulfilment of this new clinical education paradigm will not be easy. Educational inertia, conventional thinking, financial disincentives and bondage to time-based educational schedules are barriers that must be breached before SBML can be adopted in medical education.[29] These barriers can be overcome. The scientific and translational outcome paradigm shift that SBML promises for medical education – time variation, uniform outcomes – is a revolutionary idea, a disruptive innovation, the time of which has come.[73] Simulation-based mastery learning coupled with technology-enabled assessment[74] will reduce our reliance on the apprenticeship model of clinical medical education. We cannot continue to educate 21st century doctors using 19th century technologies. Medical educators should endorse, implement and evaluate mastery learning programmes across the undergraduate, graduate and continuing medical education continuum.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Table S1. Summary of a selective review of research studies that employ the mastery learning model and measure downstream translational science outcomes.

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BEME review

Best evidence on high-fidelity simulation: what clinical teachers need to know

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Since the 1980s, medical education has witnessed a significant increase in the use of simulation technology for teaching and assessment. What had previously been thought of as just a hobby for technically savvy clinical educators has now been fully integrated into the culture of clinical training. This is true not only for undergraduate medical education, but also for postgraduate training and continuing professional development. Hundreds of medical schools worldwide have already developed, or are in the process of developing, clinical skills/

The most thorough search possible of peer-reviewed publications

Providing feedback is the most important feature of simulation

simulation centres providing a wide range of simulations.[1] However, the significant allocation of funding and resources required for high-fidelity simulations demands evidence that this investment will yield positive outcomes. With this in mind, the Best Evidence Medical Education (BEME) Collaboration invited our group to review and synthesise existing evidence in educational science that addressed the question: 'What are the features and uses of high-fidelity medical simulations that lead to the most effective learning?' Our findings yielded a list of ten features that clinical teachers should be aware of and adopt when using high-fidelity simulations.

In 2005, we published a paper detailing the processes involved in a systematic literature review: the identification of articles, extraction of data, and analysis and synthesis of findings.[2] We searched five literature databases (ERIC, MEDLINE, PsycINFO, Web of Science, and TimeLIT) using 91 single search terms and concepts, and Boolean combinations of these. We also hand-searched specialist journals, posted internet queries using Google, and reviewed the 'grey literature' (for example, conference proceedings). The aim was to perform the most thorough search possible of peer-reviewed publications, as well as unpublished reports in the literature that had been judged for academic quality.

Effective learning stems from learner engagement in deliberate practice

We then employed four screening criteria to reduce the initial pool of 670 journal articles (more than 2,100 abstracts) to a focused set of 109 studies. These criteria were: (a) the elimination of review articles in favour of empirical studies; (b) the use of a simulator as an educational assessment or intervention, with learner outcomes measured quantitatively; (c) comparative research, either experimental or quasi-experimental; and (d) research that involves simulation solely as an educational intervention.

Nine independent coders extracted data systematically from the 109 eligible journal articles, each coder using a standardised data extraction protocol. Qualitative data synthesis and tabular presentation of research methods were used, because heterogeneity of research designs, educational interventions, outcome measures and the time-frame available precluded data synthesis using meta-analysis. The coding accuracy and inter-rater agreement for features of the journal articles was high. While the quality of the published research is generally weak, the weight of the best available evidence identified ten features and uses of high-fidelity medical simulations (in a range of specialties including anaesthesiology, cardiology and surgery) that lead to effective learning. We recommend that these features are considered as a minimum when using simulations in the clinical teaching and training of others.

FEEDBACK

Not surprisingly, we found that providing feedback to learners regarding their performance is the single most important feature of simulation-based medical education towards the goal of effective learning. Focused constructive feedback can also slow the decay of acquired skills, as well as allowing learners to self-assess and monitor their progress towards skill acquisition and maintenance. Sources of feedback may be 'built-in' to a simulator in such a way that learners' actions result in a direct response from the simulator. For example, while defibrillating a 'patient' in cardiac arrest, the learner can view the response on the adjacent cardiac monitor. Alternatively, clinical teachers may also give feedback in 'real time' during educational sessions, or provide it *post hoc* by viewing a video recording of the simulation-based educational activity. Remember: the source of the feedback is less important than its presence.

REPETITIVE PRACTICE

Opportunities for learners to engage in focused, repetitive practice – where the intent is skill improvement, not idle play – should be an essential learning feature of high fidelity medical simulations. Such practice involves intense and repeated learner engagement in a focused, controlled task, with the constant repetition giving learners the opportunity to detect and correct errors, polish their skills, and make their performance effortless and automatic. Recent research underscores the importance of repetition for clinical skill acquisition and maintenance,[3] and it has been shown that learners who are given opportunities for repetitive practice acquire necessary skills over shorter time periods than those with only routine exposure during clinical patient-care activities. This is an important factor when transferring the use of the learnt skills to real patients. Finally, the 'dose' of practice necessary should be determined by the learner's need rather than the instructor's demand. And simulators must be available (that is, to accommodate learner schedules) and in physically convenient locations (that is, close to hospital wards and clinics), to enable learners to practice skills repetitively.

CURRICULUM INTEGRATION

The integration of simulation-based exercises into the standard medical school or postgraduate educational curriculum is an essential feature of their effective use. Simulation-based education should not be an extraordinary activity; rather, educators should build simulations into the learners' normal training schedule and should base this instruction on the ways in which they will ultimately evaluate learner performance. Simulation should not be dependent on a single 'champion', who often has competing research and/or patient-care responsibilities, but be fully adopted within the wider educational programme of the medical school. Effective medical learning stems from learner engagement in deliberate practice, with clinical problems and devices in simulated settings in addition to patient-care experience. Medical education using simulations must be a required component of the standard curriculum, as optional exercises arouse much less learner interest.

RANGE OF TRAINING LEVELS

Learning is enhanced when trainees have the opportunity to engage in deliberate practice of medical skills across a wide range of levels of difficulty. Learners begin at the basic-skills level, demonstrate performance mastery against objective criteria and standards, and proceed to training at progressively higher levels of complexity. Each learner will have a different 'learning curve' in terms of shape and acceleration, although long-term learning outcomes, measured objectively, should be identical. Encouraging learners to master increasingly complex skills will slow the overall decay of skills over time.

MULTIPLE LEARNING STRATEGIES

The adaptability of high-fidelity medical simulations to multiple learning strategies is both a feature and a use of these educational devices. Desired outcomes, available resources, and the educational climate or culture of the institution will determine which strategies are adopted. Multiple learning strategies include, but are not limited to: (1) instructor-centred education involving either (a) large groups (for example, lectures); or (b) small groups (for example, tutorials); (2) small-group learning without an instructor; and (3) individual, independent learning. Of course, the optimal use of high-fidelity simulations in such different learning situations depends on the educational objectives being addressed and the extent of prior learning among the trainees. The bottom line is that the educational tools employed should match the stated educational goals. High-fidelity medical simulations that are adaptable to several learning strategies are more likely to fulfil this aim.

CLINICAL VARIATION

High-fidelity medical simulations that can capture or represent a wide variety of patient problems or conditions may be more useful than simulations having a

Simulation-based education should not be an extraordinary activity

High-fidelity medical simulations should feature clearly defined outcomes

Simulations allow complex clinical tasks to be broken down into their component parts

narrower focus. An exception to this, of course, is simulators designed for a specific task, such as carotid stent placement. Simulations capable of sampling from a broad universe of patient demographics, pathologies and responses to treatment can increase the number and variety of patients that learners encounter. Boosting the variety of simulated patients seen by learners also helps to standardise the clinical curriculum across educational sites. This gives ‘equity’ to smaller programmes, often in remote locations, where the range of real patients may be restricted. Such simulations can also give learners exposure and practice experience with rare, life-threatening patient problems, where the presentation frequency is low but the stakes are high. This provides more ‘contextual experiences’, which are critical to developing problem-solving skills.

CONTROLLED ENVIRONMENT

In a controlled clinical environment, learners can make, detect and correct patient-care errors with no adverse consequences, and instructors can focus on the learners rather than the patients. In contrast to the uncontrolled character of most patient-care settings, high-fidelity simulations are ideal for providing a controlled, forgiving environment. Education in a controlled environment allows instructors and learners to focus on ‘teachable moments’ without distraction, and take full advantage of opportunities for deliberate practice. This also reflects a clinical and educational culture focused on ethical training involving both learners and patients.[4]

INDIVIDUALISED LEARNING

The opportunity for learners to have reproducible, standardised educational experiences where they are active participants, rather than merely passive bystanders, is an important aspect of the use of high-fidelity medical simulations, and learning experiences can be individualised and adapted to each student’s unique learning needs. Simulations allow complex clinical tasks to be broken down into their component parts for educational mastery in sequence at variable rates, enabling learners to take responsibility for their own educational progress within the limits of curriculum governance. With individualised learning using high-fidelity medical simulations, the goal of uniform educational outcomes can be achieved despite different rates of trainee progress.

DEFINED OUTCOMES OR BENCHMARKS

In addition to individualised learning in a controlled educational environment, high-fidelity medical simulations should feature clearly defined outcomes or benchmarks for learner achievement. These are straightforward goals with tangible, objective measures of achievement. Learners are more likely to master key skills if the outcomes are defined and appropriate to their level of training.[5]

SIMULATOR VALIDITY

There are many types of educational validity, both in the presentation of learning materials and in measuring educational outcomes. A high degree of realism or fidelity provides an approximation to complex clinical situations, principles and tasks. Thus high simulator validity is important to help learners increase their visuo-spatial perceptual skills and to sharpen their responses to critical incidents. Clinical learners desire this realism (face validity) during their hands-on experiences. It is important to note, however, that the desired outcome should be matched with the appropriate degree of fidelity; a wide range of competencies can be learned and mastered with relatively low-fidelity simulators.

Many of these features are consonant with Ericsson’s model of deliberate practice to achieve mastery in professional performance.[2] Most of the features are not unique to high-fidelity simulations, but rather reflect sound principles of good educational practice. We advise clinical teachers who use simulations to train and evaluate learners to incorporate as many of these features as possible into their training programmes. The outcome of such efforts is more likely to be an effective tool that meets students' educational needs.

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6 Debriefing Using a Structured and Supported Approach

Paul E. Phrampus and John M. O'Donnell

Introduction

Debriefing is often cited as one of the most important parts of healthcare simulation. It has been described as a best practice in simulation education and is often referred to anecdotally as the point in the session "where the learning transfer takes place." How much participants learn and later incorporate into their practice depends in part on the effectiveness of the debriefing [1–3]. The purpose of a debriefing is to create a meaningful dialogue that helps the participants of the simulation gain a clear understanding of their performance during the session. Key features include obtaining valid feedback from the facilitator, verbalizing their own impressions, reviewing actions, and sharing perceptions of the experience. A skilled debriefing facilitator will be able to use "semi-structured cue questions" that serve to guide the participant through reflective self-discovery [4]. This process is critical in assisting positive change that will help participants to improve future simulation performances and ultimately improve their ability to care for patients.

Simulation educational methods are heterogeneous with deployment ranging from partial task training of entry-level students through complicated, interdisciplinary team training scenarios involving practicing professionals. Debriefing has a similar wide and varied development history and evolutionary pathway. Equipment and environmental, student, and personnel resources can greatly influence the selection of a debriefing method. Various techniques and methods have emerged over the last decade based on such factors as the level of the learner, the domain and mix of the learner(s), the amount of time allotted for the simulation exercise, equipment capability, and the physical facilities that are available including audiovisual (AV) equipment, observation areas, and debriefing rooms. Understanding personnel capability and course logistics is crucial to effective debriefing. The level of expertise of the facilitator(s) who will be conducting debriefings, the number of facilitators available, as well as their ability to effectively use the available equipment and technology all play a role in how debriefings are planned and conducted. Other factors that play a role in the design of the debriefing process tie back to the intent and goals of the simulation and how the simulation was conducted. For example, the debriefing style and method of a single stand-alone scenario may be significantly different than the debriefing of a simulation scenario that is part of a continuum of scenarios or learning activities organized into a course.

Development of the Structured and Supported Debriefing Model and the GAS Tool

The Winter Institute for Simulation Education and Research (WISER, Pittsburgh, PA) at the University of Pittsburgh, is a high-volume multidisciplinary simulation center dedicated to the mission that simulation educational methods can improve patient care. Also well recognized for instructor training, the center philosophy acknowledges that training in

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debriefing is a critical element for the success of any simulation program.

In 2009, WISER collaborated with the American Heart Association to develop the structured and supported debriefing model for debriefing of advanced cardiac life support and pediatric advanced life support scenarios [3]. It was quickly realized that the structured and supported model was scalable and could be easily expanded to meet the debriefing needs of a variety of situations and simulation events. The model derives its name from providing *structured* elements included three specific debriefing phases with related goals, actions, and time allocation estimates. *Supported* elements include both interpersonal support (including development of a safe environment) and objects or media such as the use of protocols, algorithms, and available best evidence to support the debriefing process.

The debriefing *tool* uses the structural framework GAS (gather, analyze, and summarize) as an operational acronym [3]. The final goal was to develop a highly structured approach, which could be adapted to *any* debriefing situation. Another important component was that the model would be easy to teach to a wide variety of instructional faculty with varying levels of expertise in simulation debriefing and facilitation. Structured and supported debriefing is a learner-centered process that can be rapidly assimilated, is scalable, and is designed to standardize the debriefing interaction that follows a simulation scenario. It promotes learner self-reflection in thinking about *what* they did, *when* they did it, *how* they did it, *why* they did it, and *how* they can improve as well as ascertaining if the participants were able to make cause-and-effect relationships within the flow of the scenario. The approach emphasizes both self-discovery and self-reflection and draws upon the learner's own professional experience and motivation to enhance learning. Integration of the educational objectives for each scenario into the analysis phase of the debriefing ensures that the original goals of the educational session are achieved. Further, instructor training in the use of the model emphasizes close observation and identification of gaps in learner knowledge and performance which also are discussed during the analysis phase.

The Theoretical Foundation of the Structured and Supported Debriefing Model

The initial steps in the development of the structured and supported debriefing model were to review debriefing methods and practices currently being used at WISER and determine common elements of effective debriefing by experienced faculty. The simulation and educational literature was reviewed, and the core principles of a variety of learning theories helped to provide a comprehensive, theoretical foundation for the structured and supported model.

The Science of Debriefing

Feedback through debriefing is considered by many to be one of the most important components contributing to the effectiveness of simulation-based learning [1–7]. Participants who receive and assimilate valid information from feedback are thought to be more likely to have enhanced learning and improved future performance from simulation-based activities. Indeed the topic is considered so relevant; two chapters have been devoted to debriefing and feedback in this book (this chapter and Chap. 7). In traditional simulation-based education, debriefing is acknowledged as a best practice and is lauded as the point in the educational process when the dots are connected and "aha" moments occur. While debriefing is only one form of feedback incorporated into experiential learning methods, it is viewed as critical because it helps participants reflect, fill in gaps in performance, and make connections to the real world. The origins of debriefing lie in military exercises and war games in which lessons learned are reviewed after the exercise [8]. Lederman stated that debriefing "incorporates the processing of that experience from which learners are to draw the lessons learned" [9]. Attempts to have the participant engage in self-reflection and facilitated moments of self-discovery are often included in the debriefing session by skilled facilitators.

In simulation education, the experiential learning continuum ranges from technical skills to complex problem-solving situations. Because simulation education occurs across a wide range of activities and with students of many levels of experience, it is logical for educators to attempt to match the debriefing approach with the training level of the learner, the specific scenario objectives, the level of scenario complexity, and the skills and training of the simulation faculty. Additionally, the operational constraints of the simulation exercise must be considered as some debriefing methods are more time-consuming than others. While evidence is mounting with respect to individual, programmatic, clinical, and even system impact from simulation educational approaches, there is little concrete evidence that supports superiority of a particular approach, style, or method of debriefing. In this section we present the pertinent and seminal works that have provided the "science" behind the "art" of simulation-inspired debriefing.

Fanning and Gaba reviewed debriefing from the perspective of simulation education, industry, psychology, and military debriefing perspectives. This seminal paper provides food for thought in the area and poses many questions which still have yet to be answered. The setting, models, facilitation approaches, use of video and other available technology, alternative methods, quality control initiatives, effective evaluation, time frames, and actual need for debriefing are considered. They note that "there are surprisingly few papers in the peer-reviewed literature to illustrate how to debrief, how to teach or learn to debrief, what methods of debriefing exist and how effective they are at achieving learning objectives and goals" [6]. The publication of this paper has had substantial impact on perceptions of debriefing in the simulation educational community and can be viewed as a benchmark of progress and understanding in this area. Following is a review of additional prominent papers that have been published in the subsequent 5-year interval which emphasize methods, new approaches, and the beginnings of theory development in healthcare simulation debriefing. These papers also highlight the gaps in our collective knowledge base:

- Decker focused on use of structured, guided reflection during simulated learning encounters. Decker's work in this chapter drew on a variety of theories and approaches including the work of Schön. Decker adds reflection to the work of Johns, which identifies four "ways of knowing": empirical, aesthetic, personal, and ethical. These ways of knowing are then integrated within a debriefing tool for facilitators [10].
- Cantrell described the use of debriefing with undergraduate pediatric nursing scenarios in a qualitative research study. In this study, Cantrell focused on the importance of guided reflection and used a structured approach including standardized questions and a 10-min time limit. Findings emphasized the importance of three critical elements: student preparation, faculty demeanor, and debriefing immediately after the simulation session [1].
- Kuiper et al. described a structured debriefing approach termed the "Outcome-Present State-Test" (OPT) model. Constructivist and situated learning theories are embedded in the model which has been validated for debriefing of actual clinical events. The authors chose a purposive sample of students who underwent a simulation experience and then completed worksheets in the OPT model. Key to the model is a review of nursing diagnoses, reflection on events, and creation of realistic simulations that mimic clinical events. Worksheets completed by participants were reviewed and compared with actual clinical event worksheets. The authors concluded that this form of structured debriefing showed promise for use in future events [11].
- Salas et al. describe 12 evidence-based best practices for debriefing medical teams in the clinical setting. These authors provide tips for debriefing that arise from review of aviation, military, industrial, and simulation education literature. The 12 best practices are supported by empirical evidence, theoretical constructs, and debriefing models. While the target audiences are educators and administrators working with medical teams in the hospital setting, the principles are readily applicable to the simulation environment [12].
- Dieckmann et al. explored varying debriefing approaches among faculty within a simulation facility focused on medical training. The variances reported were related to differences among individual faculty and in course content focus (medical management vs. crisis management). The faculty role "mix" was also explored, and a discrepancy was noted between what the center director and other faculty thought was the correct mix of various roles within the simulation educational environment [13].
- Dreifuerst conducted a concept analysis in the area of simulation debriefing. Using the framework described by Walker and Avant in 2005, Dreifuerst identified concepts that were defining attributes of simulation debriefing, those concepts that could be analyzed prior to or independently of construction and those concepts to be used for testing of a debriefing theory. Dreifuerst proposes that development of conceptual definitions leading to a debriefing theory is a key step toward clearer understanding of debriefing effectiveness, development of research approaches, and in development of faculty interested in conducting debriefings [14].
- Morgan et al. studied physician anesthetists who experienced high-fidelity scenarios with critical complications. Participants were randomized to simulation debriefing, home study, or no intervention (control). Performance checklists and global rating scales were used to evaluate performance in the original simulation and in a delayed posttest performance (9 months). All three groups improved in the global rating scale (GRS) of performance from their baseline, but there was no difference on the GRS between groups based on debriefing method. A significant improvement was found in the simulation debriefing group on the performance *checklist* at the 9-month evaluation point [15].
- Welke et al. compared facilitated oral debriefing with a standardized multimedia debriefing (which demonstrated ideal behaviors) for nontechnical skills. The

subjects were 30 anesthesia residents who were exposed to resuscitation scenarios. Each resident underwent a resuscitation simulation and was then randomized to a debriefing method. Following the first debriefing, residents completed a second scenario with debriefing and then a delayed posttest 5 weeks later. While all participants improved, there was no difference between groups indicating no difference in effectiveness between multimedia instruction and facilitator-led debriefing [16]. The implications for allocation of resources and management of personnel in simulation education if multimedia debriefing can be leveraged are emphasized by this paper.

- Arafeh et al. described aspects of debriefing in simulation-based learning including pre-briefing, feedback during sessions, and the need for effective facilitation skills. These authors acknowledge the heterogeneity of debriefing situations and describe three specific simulation activities and associated debriefing approaches which were matched based on the objectives, level of simulation, and learning group characteristics. They also emphasized the need for facilitator preparation and the use of quality improvement approaches in maintaining an effective program [5].
- Van Heukelom et al. compared immediate post-simulation debriefing with in-simulation debriefing among 161 third year medical students. Prior to completing a simulation session focused on resuscitation, medical students were randomly assigned to one of the two methods. The participants reported that the post-simulation debriefings were more effective in helping to learn the material and understand correct and incorrect actions. They also gave the post-simulation debriefings a higher rating. The in-simulation debriefing included pause and reflect periods. While not viewed by participants as being equally effective, the pausing that occurred was not seen as having altered the realism of the scenario by the participants [17]. This is important as some educators are reluctant to embrace a pause and reflect approach due to concern of loss of scenario integrity.
- Raemer et al. evaluated debriefing research evidence as a topical area during the Society of Simulation in Healthcare International Consensus Conference meeting in February 2011. These authors reviewed selected literature and proposed a definition of debriefing, identified a scarcity of quality research demonstrating outcomes tied to debriefing method, and proposed a format for reporting data on debriefing. Areas of debriefing research identified as having obvious gaps included comparison of methods, impact of faculty training, length of debriefing, and ideal environmental conditions for debriefing. Models for study design and for presenting research findings were proposed by this review team [18].
- Boet et al. examined face-to-face instructor debriefing vs. participant self-debriefing for 50 anesthesia residents in the area of anesthetist nontechnical skill scale (ANTS). All participants improved significantly from baseline in ANTS performance. There was no difference in outcomes between the two debriefing methods suggesting that alternative debriefing methods including well-designed self-debriefing approaches can be effectively employed [19].
- Mariani et al. used a mixed methods design to evaluate a structured debriefing method called Debriefing for Meaningful Learning (DML)©. DML was compared with unstructured debriefing methods. The unstructured debriefing was at the discretion of the faculty, but the authors noted it typically included a review of what went right, what did not go right, and what needed to be improved for the next time. The DBL approach while highly structured was also more complicated and included five areas: engage, evaluate, explore, explain, and elaborate. The authors reported that the model was based on the work of Dreifuerst. A total of 86 junior-level baccalaureate nursing students were enrolled in the study, and each student was asked to participate in two medical-surgical nursing scenarios. The Lasater Clinical Judgment Rubric was used to measure changes in clinical judgment, and student-focused group interviews elicited qualitative data. No difference was found between the groups in the area of judgment; however, student perceptions regarding learning and skill attainment were better for the structured model [20].

In the 5-year interim since Fanning and Gaba noted that the evidence was sparse regarding debriefing and that our understanding regarding key components is incomplete, there has been some progress but few clear answers. Alternatives to conventional face-to-face debriefing are being explored, theories and methods are being trialed, and several principles have become well accepted regardless of the method. These include maintaining a focus on the student; assuring a positive, safe environment; encouraging reflection; and facilitating self-discovery moments. However, the fundamental questions of who, what, when, where, and how have not been fully answered through rigorous research methodology. It is likely that a "one size fits all" debriefing model will not be identified when one considers the many variables associated with healthcare simulation. The heterogeneity of participants, learning objectives, simulation devices, scenarios, environments, operational realities, and faculty talents require a broad range of approaches guided by specific educational objectives and assessment outcomes.

In this chapter and Chap. 7, two well-established approaches to debriefing are described. Both of these approaches have been taught to hundreds if not thousands of faculty members both nationally and internationally. Both are built upon sound educational theory and have proven track records of success. Both methods have been developed by large and well-established simulation programs with senior simulation leaders involved. Termed "debriefing with good judgment" and "structured and supported debriefing," the contrast and similarities between these two approaches will serve to demonstrate the varied nature of the art and the evolving science of debriefing in simulation education. What should also be apparent is that it may be unimportant how we debrief, but that we debrief at all.

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Theories or educational models which were selected emphasized the need for a student-centric approach; recognized that students are equal partners in the teaching-learning environment; emphasized the environmental, social, and contextual nature of learning; acknowledged the need for concurrent and later reflection; and acknowledged the need for deliberate practice in performance improvement (Table 6.1).

These theories support multiple aspects of the structured and supported model for debriefing. Simulation is a form of experiential learning with curriculum designers focused on creating an environment similar enough to a clinical event or situation for learning and skill acquisition to occur. The goal is to afford participants with the learning tools to allow participant performance in actual clinical care to improve.

In order for a simulated experience to be effective, the objectives for the experience must be conveyed to the participants who are being asked to contribute to the learning environment. This involvement of participants in a truly "democratic" sense was first advocated by Dewey in 1916. Dewey also recognized the power of reflection and experiential learning [5].

Lewin described the importance of experience in his "action research" work, and Kolb extended this work in developing his Experiential Learning Theory [8, 9]. Kolb describes the importance of experience in promoting learning

Table 6.1 Educational and practice theorists and key concepts related to debriefing in simulation

Theorist	Supporting concept for debriefing
Dewey [5]	Experiential learning, reflection, democratization of education
Goffman [6]	Preexisting frameworks of reference based on prior experience (knowledge, attitude, skill) influence current actions
Bandura [7]	Social learning theory. Learning through observation, imitation, and modeling. Self-efficacy critical to learning and performance
Lewin [8] and Kolb [9]	Experiential learning theory. Learning is enhanced by realistic experience. Learning increases when there is a connection between the learning situation and the environment (synergy)
Schön [10]	"Reflective practicum" where faculty act as coach and mentor. Reflection is important both during and after simulation sessions
Lave and Wenger [11]	Situated learning theory. Learning is situated within context and activity. Accidental (unplanned) learning is common
Ericsson [12–15]	Deliberate practice leading to expertise. Performance improvement is tied to repetition and feedback

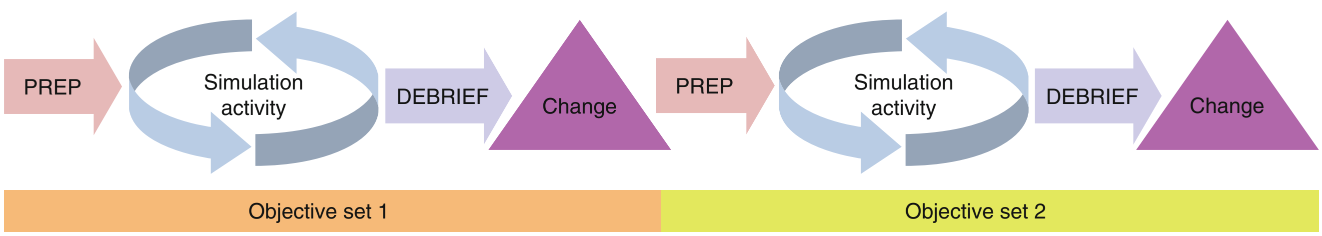

Fig. 6.1 The Ericsson cycle of deliberate practice applied to simulation sessions and incorporating debriefing and planned change

and describes the synergistic impact of environmental realism. Kolb developed a cyclical four-stage learning cycle "Do, Observe, Think, Plan" that describes how experience and action are linked. Kolb's work also emphasizes the need for reflection and analysis [9].

Goffman reported that humans have frames of reference that include knowledge, attitude, skill, and experience elements. Individuals attempt to make sense of new experiences by fitting their actions and understanding to their preexisting frameworks [6]. This is especially important in developing an understanding of "gaps" in participant performance.

Bandura developed the Social Learning Theory. This theory suggests that learning is a socially embedded phenomenon which occurs through observation, imitation, and modeling. Bandura et al. also emphasize that individual self-efficacy is crucial to learning and performance [7]. These constructs are useful in debriefing, as a group debriefing is a fairly complex social environment, and the outcome of a poorly facilitated debriefing session may be a decreased sense of self-efficacy.

Schön described the characteristics of professionals and how they develop their practice. He suggested that one key aspect of professional practice is a capacity to self-reflect on one's own actions. By doing so, the individual engages in a process of continuous self-learning and improvement. Schön suggests that there are two points in time critical to the reflection process. Reflection during an event (reflection in action) and reflection after the event is over (reflection on action) [10]. The facilitator's ability to stimulate participants to reflect on their performance is key during the debriefing process.

Lave and Wenger developed the "situated learning theory," which states in part that learning is deeply contextual and associated with activity. Further, these authors note that transfer of information from one person to another has social and environmental aspects as well as specific context. These authors also indicated that learning is associated with visualization, imitation, and hands-on experience. Accidental (and thus unscripted) learning commonly occurs and learners legitimately gain from observation of performance [11].

Ericsson describes the concept of "deliberate practice" as the route for development of new skills (up to the expert level). In this seminal work, Ericsson points out that the trainee needs to experience multiple repetitions interspersed with meaningful review and learning toward development of expertise [12–15] (Fig. 6.1).

This concept has important implications in simulation development, deployment, and debriefing and is now recognized as a best practice in simulation education [16, 17]. Other literature has emerged and should be used to inform approaches to debriefing. The following are points and best practices regarding debriefing which have been modified from the original paper by Salas which focused on team debriefing in the hospital setting [1, 3, 4, 16–24]:

- Participants want and expect debriefing to occur.
- The gap between performance and debriefing should be kept as short as possible.
- Debriefing can help with stress reduction and closure.
- Performance and perception gaps should be identified and addressed.

- Debriefing enhances learning.
- Environmental conditions are important.
- A "social" aspect must be considered and steps taken to ensure "comfort."
- Participant self-reflection is necessary for learning.
- Instructor debriefing and facilitation skills are necessary.
- Structured video/screen-based "debriefing" also works.
- Lessons can be learned from other fields (but the analogy is not perfect).
- Not everything can be debriefed at once (must be targeted or goal directed).
- Some structure is necessary to meet debriefing objectives.

Based on the theoretical perspectives and the above best practices, faculty are encouraged to ensure that they consistently incorporate several key elements within sessions in order to enhance effectiveness of debriefing:

1. Establish and maintain an engaging, challenging, yet supportive context for learning.
2. Structure the debriefing to enhance discussion and allow reflection on the performance.
3. Promote discussion and reflection during debriefing sessions.
4. Identify and explore performance gaps in order to accelerate the deliberate practice-skill acquisition cycle.
5. Help participants achieve and sustain good performance.

Although the specific structure used in debriefings may vary, the beginning of the debriefing, or the gather phase, is generally used for gauging reaction to the simulated experience, clarifying facts, describing what happened, and creating an environment for reflective learning. It also gives the facilitator an opportunity to begin to identify performance and perception gaps, meaning the differences that may exist between the perception of the participants and the perception of the facilitator.

The most extensive (and typically longest) part of the debriefing is the middle, or analysis phase, which involves an in-depth discussion of observed performance or perception gaps [2]. Performance gaps are defined as the gap between desired and actual performance, while perception gap is the dissonance between the trainee's perception of their performance and actual performance as defined by objective measures. These two concepts must be considered separately as performance and the ability to perceive and accurately self-assess performance are separate functions [25–29]. Since an individual or team may perform actions for which the rationale is not immediately apparent or at first glance seems wrong, an effective debriefing should ideally include an explicit discussion around the drivers that formed the basis for performance/perception gaps. While actions are observable, these drivers (thoughts, feelings, beliefs, assumptions, knowledge base, situational awareness) are often invisible to the debriefer without skillful questioning [6, 19–21]. Inexperienced facilitators often conclude that observed performance gaps are related only to knowledge deficits and launch into a lecture intended to remediate them. By exploring the basis for performance and perception gaps, a debriefer can better diagnose an individual or team learning need and then close these gaps through discussion and/or focused teaching.

Finally, a debriefing concludes with a summary phase in which the learners articulate key learning points, take-home messages, and needed performance improvements, as well as leading them to an accurate understanding of their overall performance on the scenario.

Developing Debriefing Skills

Faculty participating in debriefing must develop observational and interviewing skills that will help participants to reflect on their actions. As in any skill attainment, deliberate practice and instructor self-reflection will assist with skill refinement. New facilitators are often challenged in initiating the debriefing process and find it useful to utilize a cognitive aid such as the GAS debriefing tool (Table 6.2). The use of open-ended questions during debriefings will encourage dialogue and lead to extended participant responses. While it is important to ask open-ended questions, it is equally important for the facilitator to establish clear parameters in order to meet the session objectives. For example, the question "Can you tell us what happened?" may be excessively broad and nondirectional. Alternatively, "Can you tell us what happened between the time when you came in the room and up until when the patient stopped responding?" remains open ended but asks the participant to focus on relevant events as they occurred on a timeline [2, 30].

Some simulation educators suggest that close-ended question (questions that limit participant responses to one or two words) be avoided entirely. However, they are often useful in gaining information about key knowledge or skill areas if phrased appropriately, especially in acute-care scenarios. For example, "Did you know the dose of labetalol?" will provoke a yes or no response and may not provide valuable information for facilitator follow-up or stimulate participant reflection. Alternatively, "What is the dose of labetalol and how much did you give?" provides a more fertile environment for follow-up discussion.

Several communication techniques can be used which promote open dialogue. Active listening is an approach in which the facilitator signals to the participants (both verbally and nonverbally) that their views, feelings, and opinions are important. Key facilitator behaviors include use of nonverbal clues such as appropriate eye contact, nodding, and acknowledging comments ("go ahead," "I understand"). Restating trainee comments (in your own words) and summarizing

Table 6.2 Structured and supported debriefing model. The model consists of three phases with corresponding goals, actions, sample questions, and time frames

Phase	Goal	Actions	Sample questions	Time frame
Gather	Listen to participants to understand what they think and how they feel about session	Request narrative from team leader Request clarifying or supplemental information from team	All: How do you feel? Team Leader: Can you tell us what happened when….? Team members: Can you add to the account?	25%
Analyze	Facilitate participants' reflection on and analysis of their actions	Review of accurate record of events Report observations (correct and incorrect steps) Ask a series of question to reveal participants' thinking processes Assist participants to reflect on their performance Direct/redirect participants to assure continuous focus on session objectives	I noticed… Tell me more about… How did you feel about… What were you thinking when… I understand, however, tell me about the "X" aspect of the scenario… Conflict resolution: Let's refocus—"what's important is not who is right but what is right for the patient…"	50%
Summarize	Facilitate identification and review of lessons learned	Participants identify positive aspects of team or individual behaviors and behaviors that require change Summary of comments or statements	List two actions or events that you felt were effective or well done Describe two areas that you think you/team need to work on…	25%

their comments to achieve clarity are also effective forms of active listening [2, 31].

A second effective debriefing technique is the use of probing questions. This is a questioning approach designed to reveal thinking processes and elicit a deeper level of information about participant actions, responses, and behaviors during the scenario. Many question types can be selected during use of probing questions. These include questions designed to clarify, amplify, assess accuracy, reveal purposes, identify relevance, request examples, request additional information, or elicit feelings [2, 30].

A third technique is to normalize the simulation situation to something familiar to the participants. For example, the facilitator can acknowledge what occurred during the session and then ask the participants "Have you ever encountered something similar in your clinical experience?" This grounds the simulation contextually and allows the participant to connect the simulation event with real-life experience which has the benefit of enhancing transfer of learning.

Another key skill in maintaining a coherent debriefing is redirection. The facilitator needs to employ this skill when the discussion strays from the objectives of the session or when conflict arises. Participants sometimes are distracted by technological glitches or the lack of fidelity of a particular simulation tool. The facilitator task is to restore the flow of discussion to relevant and meaningful pathways in order to assure that planned session objectives are addressed.

Structured and Supported Debriefing Model: Operationally Described

The operational acronym for the structured and supported debriefing model is GAS. GAS stands for gather, analyze, and summarize and provides a framework to help the operational flow of the debriefing, as well as assisting the facilitator in an organized approach to conducting the debriefing (Table 6.2). While there is no ideal time ratio for simulation time to debriefing time, or ideal time for total debriefing, operational realities usually dictate the length of time that can be allocated on the debriefing phase of a simulation course. Using the GAS acronym also provides the facilitator with a rough framework for the amount of time spent in each phase. The gather phrase is allocated approximately 25% of the total debriefing time, the analyze phase is given 50%, and finally the summarize phase is allotted approximately 25%.

Gather (G)

The first phase of the structured and supported model is the gather phase. The goals of this phase are to allow the facilitator to gather information that will help structure and guide the analysis and summary phases. It is time to evoke a reaction to the simulation from participants with the purpose of creating an environment of reflective learning. It is important

Table 6.3 Perception gap conditions

		Student perceptions	
		Performed well	**Performed poorly**
Facilitator perceptions	**Performed well**	Narrow	Wide
	Performed poorly	Wide	Narrow

to listen carefully to the participants to understand what they think and how they feel about the session. Critical listening and probing questions will allow the facilitator to begin to analyze the amount of perception gap that may exist. The perception gap is the difference of the overall opinion of the performance as judged by the participants themselves vs. the opinion of the facilitator. Essentially four conditions can exist, two of which have wide perception gaps in which there is significant discordance between perceptions of the participant and facilitator and two that have narrow perception gaps (Table 6.3). This awareness of the perception gap is a critical element of helping to frame the remainder of the debriefing.

To facilitate the gather phase, the instructor embarks in a series of action to stimulate and facilitate the conversation. For example, the debriefing may begin by simply asking the participants how they feel after the simulation. Alternatively if it is a team-based scenario, facilitators may begin by asking the team leader to provide a synopsis of what occurred during the simulation and perhaps inquire if the participants have insight into the purpose of the simulation. The facilitator may then ask other team members for supporting information or clarifying information, the goal being to determine each of the participant's general perception of the simulation. During the gathering phase open-ended questions are helpful to try to elicit participant thoughts or stream of consciousness so that the facilitator can gain a clear understanding of the participant perceptions. During this phase it is often useful to develop an understanding of whether there is general agreement within the participant group or if there are significant disagreements, high emotions, or discord among the group.

The gather phase should take approximately 25% of the total debriefing time. Once the gather phase is completed, and the facilitator feels that they have elicited sufficient information to proceed, there is a segue into the analyze phase.

Analyze (A)

The analyze phase is designed to facilitate participants reflection *on* and analysis *of* their actions and how individual and team actions may have influenced the outcome of the scenario, or perhaps changes that may have occurred to the patient during the scenario.

During the analyze phase, participants will often be exposed to review of an accurate record of events, decisions, or critical changes in the patient in a way that allows them to understand how the decisions that they made affected the outcomes of the scenario. Simulator log files, videos, and other objective records of events (when available) can often be helpful as tools of reference for this purpose.

Probing questions are used by the facilitator in an attempt to reveal the participants thinking processes. Cueing questions should be couched in a manner that stimulates further reflection on the scenario and promotes self-discovery into the cause-and-effect relationships between decisions and the scenario outcome. For example, a question such as "Why do you think the hypotension persisted?" may allow the participants to realize they forgot to give a necessary fluid bolus.

It is crucial that the facilitator be mindful of the purpose of the session and that the questions selected direct the conversation toward accomplishing the learning objectives (Fig. 6.2). During a simulation scenario, there are many things that occur that *can* be talked about, but it is important to remember that for a variety of reasons, it usually isn't possible to debrief everything. It is the learning objectives that should help to create the screening process that determines what *should* be talked about. Skilled facilitators must continuously direct and redirect participants to assure continuous focus on session objectives, and not let the debriefing conversation stray off-topic.

The skilled facilitator must also continuously be aware of the need for assisting in conflict resolution during the analyze phase. It is important for participants to not focus on who was right and who was wrong but rather encourage an environment of consideration for what would've been right for the comparable actual clinical situation.

The analyze phase is also an ideal time to incorporate the use of cognitive aides or support materials during the discussion. Practice algorithms, professional standards, Joint Commission guidelines, and hospital policies are examples of materials that can be used. These tools allow participants to compare their performance record with the objective-supporting materials and can assist in developing understanding, in providing rationale, and in narrowing the perception gap. It also serves to begin the process of helping learners in calibrating the accuracy of their perception and gaining a true understanding of their overall performance. Importantly, these "objective materials" allow the instructor to defuse participant defensiveness and reduce the tension that can build during a debriefing of a suboptimal performance. Having the participant use these tools to self-evaluate can be useful. Additionally, depending on the design of the scenario and supporting materials, it may be prudent to review completed assessment tools, rating scales, or checklists with the participant team.

Because the analyze phase is designed to provide more in-depth understanding of the participants mindset, insights,

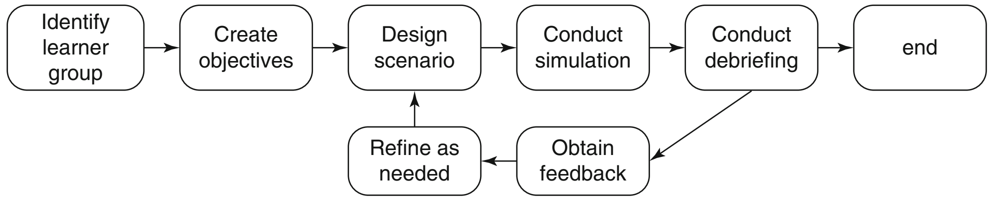

Fig. 6.2 Connection between simulation session objectives and debriefing session (With permission ©Aimee Smith PA-C, MS, WISER)

and reflection of the performance, it is allocated 50% of the total debriefing time. As the goals of the analyze phase are achieved, the facilitator will then transition to the summarize phase.

Summarize (S)

The summarize phase is designed to facilitate identification and review of lessons learned and provide participants with a clear understanding of the most important take-home messages. It continues to employ techniques that encourage learners to reflect over the performance of the simulation. It is designed to succinctly and clearly allow learners to understand their overall performance as well as to reinforce the aspects of the simulation that were performed correctly or effectively, as well as to identify the areas needing improvement for future similar situations.

It is important that the summarize phase be compartmentalized so that the takeaway messages are clearly delivered. Often in the analyze phase, the discussion will cover many topics with varying levels of depth and continuity which can sometimes leave the learners unaware of the big picture of the overall performance. Thus, it is recommended that transition into the summarize phase be stated clearly such as the facilitator making the statement "Ok, now let's talk about what we are going to take away from this simulation."

Incorporating structure into the summarize phase is critical. Without structure, it is possible that the key take-home messages which are tied to the simulation session objectives will be missed. In the structured and supported model, a mini plus-delta technique is used to frame the summarize phase [22]. Plus-delta is a simple model focused on effective behaviors or actions (+) and behaviors or actions which if changed would positively impact performance (Δ). An example of using the plus-delta technique would be asking each team member to relate two positive aspects of their performance, followed by asking each team member to list two things that they would change in order to improve for the next simulation session (Fig. 6.1). This forcing function tied to the plus (positives) and delta (need to improve) elements allows students to clarify, quantify, and reiterate the takeaway messages. At the very end of the summarize phase, the facilitator has the option to explicitly provide input to the participants as to their overall performance rating relative to the scenario if deemed appropriate. This will vary in accordance to the design of the scenario and the assessment tools that are used, or if the assessment is designed to be more qualitative, it may just be a summary provided by the facilitator.

Variability in Debriefing Style and Content

The structured and supported debriefing model provides a framework around which to guide the debriefing process. Entry-level facilitators as well as those who are very experienced are able to use it successfully. There are many factors that determine how long the actual debriefing will take and what will be covered in the debriefing. While there is attention to best practices in debriefing, operational realities often determine how the debriefing session for a given simulation takes place.

The learning objectives for the scenario serve as the initial basis for determining what the actual content of the debriefing should contain. As mentioned previously it is rarely possible to debrief everything that occurs in a given simulation. This is for two principal reasons, the first being the practicality of time and how long participants and faculty member have available to dedicate to the simulation activity. The second is learner saturation level, which is to say there is a finite amount of feedback and reflection possible in a given amount of time.

Other considerations are the structure of the simulation activity. If the simulation is a "stand-alone" or once and done, which is often the case when working with practicing professionals, then debriefing is usually more in-depth and may cover areas including technical as well as nontechnical components. The debriefing may be split into multiple focal areas that allow concentration on particular practice areas or skills (communication, procedural skills, and safety behaviors) for a given point in time.

Phased-domain debriefing is sometimes employed for interprofessional simulation. In phased-domain debriefing, the team is debriefed on common tasks (communications, teamwork, leadership, and other nontechnical skills) followed by a period of time afterward in which team members adjourn and reconvene in their separate clinical domain areas to allow for a more domain-specific discussion (Fig. 6.3).

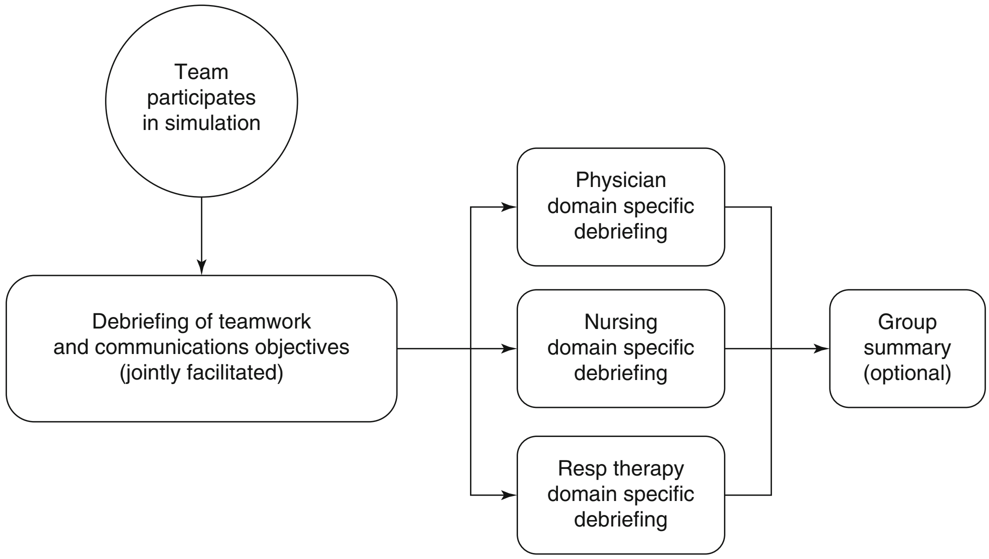

Fig. 6.3 Phased-domain debriefing in simulation. The original group composed of physicians, nurses, and respiratory therapists conducted a team simulation scenario. Debriefing can be divided by clinical domain and separated into group versus domain phases

The structured and supported debriefing model has been successfully deployed in this environment as well.

Simulation scenarios that are part of a course that may include many different learning activities including several simulations are handled somewhat differently. In this example it is very important that the facilitator be aware of the global course learning objectives as well as the individualized objectives for the scenario they are presiding over. This affords the facilitator the ability to limit the discussion of the debriefing for a given scenario to accomplish the goals specific to that scenario, knowing that other objectives will be covered during other educational and simulation activities during the course. This "allocation of objectives" concept is necessary to satisfy the operational realities of the course, which are often time-based and require rotations throughout a given period of time.

Technical resource availability is another consideration in the variability of debriefing. Technical resources such as the availability of selected element video and audio review, simulator log files, projection equipment, access to the Internet and other media, and supporting objects vary considerably from one simulated environment to the next.

The level of the participants and the group dynamics of the participants can factor into the adaptation of best-practice debriefing. Competing operational pressures will often create some limitations on the final debriefing product. For example, when teams of practicing professionals are brought together for team training exercises, they are often being pulled away from other clinical duties. Thus, the pressure is higher to use the time very efficiently and effectively. This is in contrast to student-level simulations, where the limiting factor can be the sheer volume of students that must participate in a given set of simulation exercises.

Challenges in Debriefing

There are a number of challenges associated with debriefing. Some of them involve self-awareness on the part of the facilitator, the skill of the facilitator, as well as resource limitations mentioned earlier. One of most difficult challenges is the need for the facilitator to be engaged in continuous assessment in order to maintain a safe learning environment for the participants.

Controlling the individual passion focus is an important consideration for facilitators and requires self-awareness in order to avoid bias during debriefing. As clinical educators from a variety of backgrounds, it is normal for a facilitator to have a specific passion point around one or more areas of treatment. This can lead the facilitator to subconsciously pay closer attention to that particular area of treatment during the simulation and subsequently focus on it during the debriefing. It is particularly important to maintain focus on the simulation exercise learning objectives when they are not designed in alignment with the passion focus of the facilitator. The facilitator must resist the urge to espouse upon their favorite clinical area during the debriefing. Otherwise the learning objectives for the scenario may not be successfully accomplished.

At times during simulation exercises, egregious errors may occur that need to be addressed regardless of whether they were part of the learning objectives or not. Typically these errors involve behaviors that would jeopardize patient safety in the clinical setting. If the topic surrounding the error is not part of the focal learning objectives for the simulation scenario, it is best to make mention of it, have the participants understand what the error was, describe an appropriate safe response, and then quickly move on. Let the participants know that the area or topic in which the error occurred is not the focus of the simulation, but emphasize that it is important that everyone be aware of safety issues.

The maintenance of a safe learning environment is another aspect of facilitator skill development. For example, difficult participants are sometimes encountered, emotionally charged simulations or debriefings occur and students may fail to "buy in" to the educational method. All of these situations are under the purview of the facilitator to assist in the process that allows self-discovery and allow freedom on the part of the participants to express their thoughts, concerns, and in particular their decision-making thought processes. The facilitator must always be ready to intervene in a way that attempts to depersonalize the discussion to provide a focus on the best practices that would've led to the best care for the patient.

Other factors of maintaining a safe learning environment are typically covered in the orientation to the simulation exercises. Informing participants ahead of time of grading processes, confidentiality factors, and the final disposition of any video and audio recordings that may occur during a simulation will go a long way toward the participant buy-in and comfort level with the simulation process.

Conclusion

The structured and supported model of debriefing was designed as a flexible, learner-centric debriefing model supported by multiple learning theories. The model can be used for almost every type of debriefing ranging from partial task training to interprofessional team sessions. The operational acronym GAS, standing for the phases of the method, gather, analyze, and summarize, is helpful for keeping the debriefing organized and effectively utilized. It is a scalable, deployable tool that can be used by debriefers with skills ranging from novice to expert.

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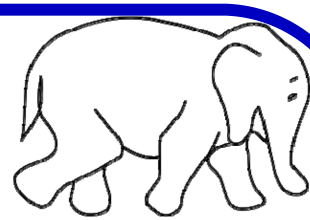
Phase	Goal	Actions	Sample Questions	Time
Gather	Listen to participants to understand what they think & how they feel about session	• Request narrative from team leader • Request clarifying or supplemental information from team	All: How do you feel? Team Leader: Can you tell us what happened? Team members: Can you add to the account?	25 %
Analyze	Facilitate participants reflection ***on*** & analysis ***of*** their actions	• Review of accurate record of events •Report observations (correct & incorrect steps) •Ask a series of question to reveal participants' thinking processes •Assist participants to reflect on their performance •Direct/redirect participants to assure continuous focus on session objectives	•I noticed… •Tell me more about… •How did you feel about… •What were you thinking when… •I understand, however, tell me about "X"_aspect of the scenario… •Conflict resolution: •Let's refocus- "what's important is not who is right but what is right for the patient…"	50 %
Summarize	Facilitate identification & review of lessons learned	•Participants identify positive aspects of team or individual behaviors & behaviors that require change •Summary of comments or statements	•List two actions or events that you felt were effective or well done •Describe two areas that you think you/team need to work on…	25 %

G

Emotional Readiness?

Their Recollection?



A

Obj 1
Obj 2
Obj 3

S

Score?

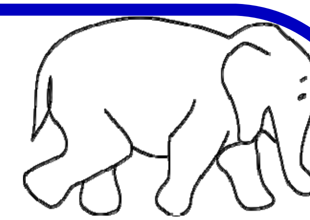
Performance?

2 Item take away (+/Δ)

G

Emotional Readiness?

Their Recollection?



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Obj 1
Obj 2
Obj 3

S

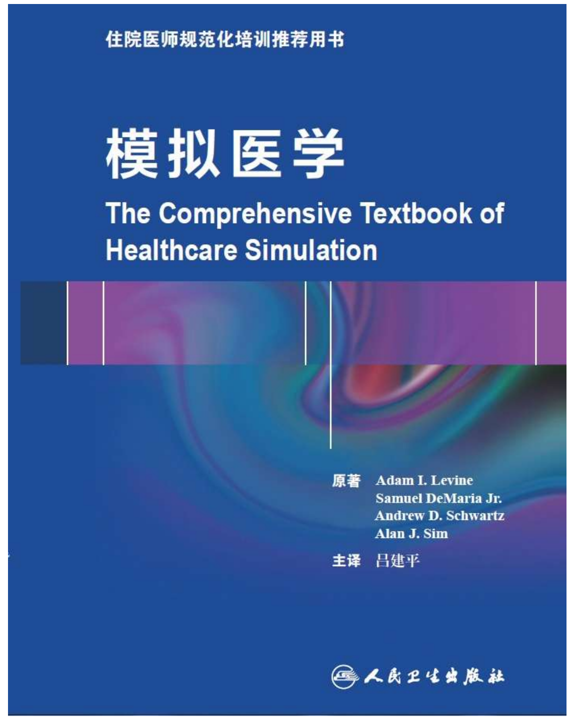
Score?

Performance?

2 Item take away (+/Δ)

《模拟医学》教材说明

关于课程中未详尽介绍的模拟医学的相关名词定义，历史来源及部分模拟医学理论等，建议参考《模拟医学》教材。



此书由美国西奈山伊坎医学院麻醉学系 Adam I. Levine 教授编写，他亦是该学院 HELPS 模拟中心主任，曾编写多部教科书，也是 Anesthesiology and Otolaryngology 教材的主编。

此书于 2017 年翻译经吴阶平医学基金会引进并翻译成中文版本，并由人民卫生出版社出版发行。

此书重点介绍了模拟医学的发展过程、理论基础、研究进展、常用方法和技术等内容；详细介绍了模拟医学教育在医学领域各个学科中的应用情况、以及模拟医学课程体系的建设，包括教学内容和师资队伍培训等。本书还专门介绍了各种各样的模拟设备（包括高仿真模拟人和虚拟现实模拟器等），也对模拟医学的未来发展趋势进行了展望，指明了将来的研究方向。

GLOSSARY OF TERMS

Accompanying Material: The information that companies a scenario that is not covered in setup.

Assessment: A tool, which collects data from the participant, for example a quiz, a survey, or an evaluation.

Class: A given instance of the delivery of a course. It may be grouped into one to many days.

Cognitive Aid: Information given to the participant about a particular method of care or guideline of care. Examples may include a difficult airway algorithm or an ACLS guideline.

Contextual Clue: Information given to the participant to provide further information with regard to the actual environment being simulated.

Course: The highest order definition of a group of learning or assessment activities surrounding any number of topics. In general it describes a high-level organization, systematized prescribed series of a program of instruction and/or assessment.

Debriefing: A post-simulation session designed to promote reflective learning typically conducted immediately after the simulation session and focused on specific participant performance or behavior elements.

Didactic Lesson: A potential session activity that attempts to convey knowledge. Examples include online modules, lectures, and PBL sessions.

Engineering fidelity: Refers to the degree to which the simulation device or training setting reproduces the physical characteristics of the real task.

Environment: The surroundings in which the scenario will be executed. Examples may include a standardized simulation room or an ambulance mockup.

Environmental Fidelity: Refers to the degree to which the simulator replicates motion cues, visual cues, or other sensory information from the task environment.

Equipment: The simulation apparatus that is necessary to execute the scenario.

Evaluation: A collection of information for the instructor to appropriately execute the scenario.

Feasibility: degree to which an activity is capable of being accomplished or carried out successfully.

Fidelity: The degree to which a device (simulator) or condition (scenario) accurately reproduces the reality of the corresponding clinical situation. Or, 1: the accuracy of the representation when compared to the real world. 2: (a) the similarity, both physical and functional, between the simulation and that which it simulates, (b) a measure of the realism of a simulation, or (c) the degree to which the representation within a simulation is similar to a real world object, feature, or condition in a measurable or perceivable manner.

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Formative Evaluation: A process for determining the competence of a person engaged in a healthcare activity for the purpose of providing constructive feedback for that person to improve.

Full Task Training: An approach to simulation education in which the environment, simulator, or curriculum are used to represent an entire clinical situation, process or interaction.

Guided Reflection: Refers to a skill, more accurately a cluster of skills, involving observation, asking questions and putting facts, ideas and experiences together to add new meaning to them all.

Healthcare Simulation: Curriculum designed to mimic the reality of a clinical environment, realistically demonstrating procedures and stimulate decision-making or critical thinking for healthcare education using role-play, manikins, representative objects, and/or interactive videos.

Instructor: The teacher or trainer during the simulation session; participates by observing and documenting actions of the participants and providing feedback during the debriefing session.

Instructor Notes: A collection of information for the instructor to appropriately execute the scenario.

Learning objective: Measurable expectations of behavioral attributes to be accomplished by the participant. These objectives can be measured through formative assessments, summative assessments, and authentic experience.

Lecture: A lecture is an oral presentation intended to present information or teach people about a particular subject, for example by a university or college teacher. Lectures are used to convey critical information, history, background, theories and equations.

Module: Logical group of learning activities generally surrounding a particular topic germane to a course. Examples include but are not limited to; recorded PowerPoint, video review, assigned reading, cognitive aids, etc.

Overall Course Objective/Description Summary: Statement describing the principle objective and rationale of the course.

Part or Partial-Task Training: An approach to simulation education in which the environment, simulator, or curriculum are used to represent a specific or limited task, process or interaction.

Participant: The person who has been identified as a member of the target audience for the simulation experience; the learner.

Post-class Material: Any number of modules or assessment tools to be completed by the participant after the class has ended. Common examples may include an end of class quiz or an evaluation of the class. Information may be available to the participant after the class in the form of reference or review materials for the participants to reflect back the content of the class.

Problem-based Learning (PBL): Refers to a student-centered instructional strategy in which students collaboratively solve problems and reflect on their experiences. Characteristics of PBL are: learning driven by challenging, open-ended problems, students work in small collaborative groups, and teachers take on the role as "facilitators" of learning.

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Psychological fidelity: Refers to the degree to which the trainee perceives the simulation to be a believable surrogate for the trained task.

Quiz: brief assessments used in education and similar fields to measure growth in knowledge, abilities, and/or skill

Reliability: degree to which a test consistently measures whatever it is supposed to measure.

Ring of Knowledge (ROK) Cards: Used in the clinical environment as quick, pocket reference guides for healthcare providers. The portability of Ring of Knowledge cards arm providers with easy access to key practices and policies in an effort to promote safe patient care delivery.

Scenario: A potential session activity where the participant takes part in some form of simulated event and is expected to perform certain tasks. This may include an activity such as the interaction with a computerized human simulator.

Session: Any activity that will occur during a given block of time, during a given day, of a given class. Example activities may be a dynamic scenario, a skills station, a didactic lesson, or an assessment.

Setup: The collective background information that is needed to execute the scenario as designed.

Simulation Class: A given instance of the delivery of a simulation course. It may be grouped into one or multiple days.

Simulation Scenario: A session with a specific learning objective(s) where the participant takes part in some form of simulated event and is expected to perform certain tasks. This may include interactions with a computerized human simulator, a part-task trainer, or a simulated patient.

Simulation Session: Any activity that can occur during a given block of time, during a given day, of a given class. Examples include a dynamic scenario, a skill station, a didactic lesson, or an assessment session.

Simulator: A device or machine that simulates an environment for training purposes.

Skills Station: Some form of skills training event for participants. This may include cycle motor skills training for a partial task trainer or refreshing cognitive skills such as structured communications. In general it is in the context of not having to interpret dynamic physiologic data to render decision-making.

Summative Evaluation: A process for determining the competence of a person engaged in a healthcare activity for the purpose of certifying with reasonable certainty that they are able to perform that activity in practice

Survey: a detailed investigation of the behavior, opinions, etc., of a group of people. A gathering of a sample of data or opinions considered to be representative of a whole.

Technical Program: Any technical information or background scripting that needs to be accomplished to execute the scenario. An example is a SimMan scenario programmed into the simulator.

Validity: the extent to which an assessment measures what it is supposed to measure

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iSIM Journey to Simulation 模拟之路JTS（入门课程）

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模拟教学入门课程，主要介绍模拟教学的精要，包括在orientation、simulation facilitation及debriefing三个环节的模拟教学授课技巧等。适用于刚接触模拟教学的初学者。
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导师与学生比例：4:32

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课程不限于应用模拟手段进行临床思维教学。
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iSIM Instructor / Course Director

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iSIM Debriefing skill

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（此课程建议参加完Fundamental和Master或者Advanced Debriefing课程后参加）

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课时：三天

- 姓　　名：
- 上课时间：
- 上课地点：