Clinical Teaching as Tutoring: Theory-Driven Clinical Education

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Abstract

Research on effective teaching in the clinical years of medical school lacks robust educational theory. The medical education literature contains a variety of models to guide clinical teachers in their practice, however these models are step-wise prescriptions that do not assist educators in understanding how they should teach or why their teaching might be effective. The One-Minute Preceptor (OMP) model is a well-known teaching prescription that serves as a starting point for making student thinking and clinical reasoning visible. By combining multiple *microskills* of the OMP model, a teaching session with a clinical faculty member looks similar to that of a tutoring episode. Re-conceptualizing the teaching of medical learners in the clinical setting as that of a tutoring relationship affords a strong theoretical lens to understand learning and instruction and allows for the application of empiric science on tutoring. The assessment of student competency in this arrangement also becomes easier for faculty to accomplish. By understanding the concept of scaffolding as well as the findings in human tutoring of student-construction and collaborative problem solving, clinical teachers can promote deeper learning through a more dynamic teaching process. Using analogical encoding through the technique of contrasting cases provides clinical educators a way of focusing learners' attention on the most important facets of clinical problems and facilitates transfer for future use. Medical educators should work on translating what is known in the learning sciences into practice in their role as teachers of medicine.

Clinical Teaching as Tutoring: Theory-Driven Clinical Education

Introduction

Clinical teaching at an academic medical center occurs in the context of the patient care workflow, which provides an authentic setting for learners both at the medical student and junior physician level. The majority of this teaching occurs in the setting of case-based discussions about patients that a given medical team is caring for on a particular day. These discussions predominantly occur on *rounds* in the morning, when the team of medical students and resident physicians presents patient cases to the faculty member ultimately responsible for patient care. The case presentations, delivered by a junior learner on the team, follow a relatively standard format, which should include an assessment of the patient's condition and a plan of care for the day. Generally, there is a subsequent discussion about the patient's diagnosis, disease process, or management plan that provides an opportunity for the faculty member to teach junior learners.

From the perspective of the faculty member responsible for attending on a team of trainees, a general model of instruction has been noted. In observing a number of institutionally identified expert clinical teachers, David Irby's (1992) qualitative work extracted three temporally discrete periods of a teacher's activities as they relate to inpatient teaching. The three components are (a) *before rounds:* planning; (b) *during rounds* (which has three subcomponents): diagnosing the patient, diagnosing the learner, and interactive thinking and teaching; (c) a*fter rounds:* reflection. While this general pattern was observed among many of the clinical educators, Irby also noted that most attending clinicians seemed to conduct their interactive teaching using a variety of rehearsed curriculum scripts, often varying from teacher to teacher, even on the same topic of discussion.

When considered through the lens of the faculty member as a physician, however, teaching during rounds becomes a much more complex task. The attending physician must first focus on providing high-quality care to his or her patients, which requires a considerable amount of cognitive resources during a case presentation. While the attending physician is entertaining the diagnostic and management possibilities, he or she must additionally be cognizant of the educational aspect of rounds. Decisions regarding what to discuss, how to discuss it, and whom on the team to discuss it with must happen quickly in an effort to maintain efficiency and keep the focus on providing care for those ill patients admitted to the hospital.

Adding a further layer of cognitive complexity to the educational mission of faculty at an academic medical center is the responsibility of assessing learners. While a national discussion about assessing medical students in the clinical setting is ongoing, (Alexander, Osman, & Walling, 2013; Hemmer & Durning, 2013), faculty member interactions with students on rounds currently serve as the greatest source of data for these evaluations. Since the competence of medical learners is highly dependent upon content area (van der Vleuten, 1996), evaluators are charged with the difficult task of evaluating students based on their context-specific knowledge and clinical skills rather than on their general traits. Recent work has shown, however, that physicians frequently fail to notice deficiencies in trainee skills (Holmboe, Sherbino, Long, Swing, & Frank, 2010) and are prone to a number of biases (Epstein & Hundert, 2002) including contrast effects, whereby learners are more likely to be contrasted with their peers than compared to an normative standard (Yeates, O'Neill, Mann, & Eva, 2012).

Current State of the Clinical Teaching Literature

Investigations into both describing how teaching actually occurs on rounds in the clinical environment and assessing what factors contribute to excellent teaching have been conducted in an effort to provide physicians, who have no formal training in education, with some guidance about how to improve their teaching. Some of the earliest work conducted by David Irby focused on the characteristics of the teachers themselves and how these characteristics, rather than specific pedagogical skills or techniques, correlated with students' ratings of overall effectiveness (Irby, 1978; Irby, Ramsey, Gillmore, & Schaad, 1991; Irby & Rakestraw, 1981). More recently, as the body of literature concerning clinical education has grown over the past thirty years, some authors have conducted extensive reviews and attempted to operationalize clinical teaching as a competency (Srinivasan et al., 2011), highlighting such behaviors as questioning skills and encouraging active student participation as key components of clinical education (Sutkin, Wagner, Harris, & Schiffer, 2008). Little work has been conducted at the fine-grain level of exploring what pedagogical moves clinical teachers actually utilize (Nilsson, Pennbrant, Pilhammar, & Wenestam, 2010), and no investigation has been conducted to see which ones correlate best with learning outcomes.

A number of authors have described a variety of step-wise teaching models to aid academic physicians in their roles as clinical teachers, specifically aiming to assist in instruction around clinical reasoning. One of those models is the One Minute Preceptor (OMP) (Neher, Gordon, Meyer, & Stevens, 1992), which was originally developed by family physicians for utilization in the outpatient setting, and has since been employed in the inpatient setting as well. This model is considered in depth in the next section of this paper, but, briefly, it requires teachers to utilize five *microskills* or chronologically executed teaching tasks:

1. Get a commitment from the learner about the answer to the problem at hand.
2. Probe for supporting evidence.
3. Teach general rules.

4. Reinforce what was done right.

5. Correct mistakes.

Other models of clinical teaching include the SNAPPS model and the newly developed MiPLAN system. The SNAPPS model (T. M. Wolpaw, Wolpaw, & Papp, 2003) is a less validated, stepwise model for learner-centered teaching in the outpatient setting. It proceeds:

1. Summarize briefly the history and findings.

2. Narrow the differential to two or three relevant possibilities.

3. Analyze the differential by comparing and contrasting the possibilities.

4. Probe the preceptor by asking questions about uncertainties, difficulties or alternative approaches.

5. Plan management for the patient's medical issues.

6. Select a case-related issue for self-directed learning.

The MiPLAN system is a recently developed, complex, inpatient-focused teaching model developed at the University of Colorado (Stickrath, Aagaard, & Anderson, 2013):

1. Meet with the team to discuss expectations.

2. Five "I" behaviors for the teacher (introduction to patient, in the moment listener, inspection of patient, interruption minimization, independent thought encouragement.

3. PLAN (patient care, learners' questions, attending's agenda, next steps).

While providing a large number of possibilities for the combination of various steps to suit teacher and student preferences as well as the learning environment, little effort has been dedicated to explaining the theoretical justification for such teaching models, and no author has attempted to determine which of these many of steps is most important for learning outcomes.

With clearly varying models to choose from, clinical teachers are faced with a decision of which model to follow, if any, with little evidence or theory on which to base their choice.

Better Theory and More Evidence

Concurrent with work on describing clinical teaching and the development of prescriptive teaching behaviors has been a push from a number of prominent medical educators for more scholarship dedicated to the purpose of answering the questions *how* and *why* certain aspects of medical education are effective (Cook, Bordage, & Schmidt, 2008; Regehr, 2010). Studies that seek to answer the questions of *how* and *why* particular educational interventions work are few and far between. Consequently, little effort has been made to expose and understand the conceptual and theoretical frameworks under which medical education operates (Cook et al., 2008).

Medical school leaders recently called fundamental reform in how medical schools teach basic science in the pre-clinical years, hoping to learn from and build on work in the learning sciences (Lambert, Lurie, Lyness, & Ward, 2010). As medical education in the United States transitions from a didactic-focused pre-clinical curriculum to a more context and case-based curriculum, either by way of problem-based learning or the flipped-classroom model (Prober & Heath, 2012), we should also reconsider our models for clinical education. While it is not the scope of this paper to describe a large curricular reform for the clerkship or clinical years of medical school, it is a call for medical educators to change their understanding of what makes for good clinical teaching where it is most crucial: in caring for patients. There is a plethora of unexplored evidence from the learning science literature that medical educators should work to apply to their clinical teaching in the hope of abandoning the current practice of teaching how one was taught.

This paper will elaborate on one of the more popular clinical teaching models, the One-Minute Preceptor, by arguing that while it provides a strong launching point for effective clinical teaching, it is merely a step-wise prescription that would benefit from the robust application of educational theory. By utilizing the One Minute Preceptor model and viewing the encounter between teacher and learner as that of a tutoring dyad, physicians can view their teaching through case discussions as synonymous with a problem presented during a tutoring episode. In using analogical encoding by posing contrasting cases during the One Minute Preceptor encounter, clinical teachers can not only benefit from a better lens through which to view their teaching, but also can be armed with a powerful educational tool to assist students in the development of their clinical reasoning while simultaneously assessing competence.

The One-Minute Preceptor Model

As introduced above, the One-Minute Preceptor is an outpatient-focused model for assisting faculty physicians with teaching medical students and junior level physicians. Introduced in 1992 in the *Journal of the American Board of Family Practice* by faculty at the University of Washington in Seattle (Neher et al., 1992), the authors originally named the model the Five-step *Microskill* Model of clinical teaching, focusing attention on five *microskills* that, if practiced in a certain order, were hypothesized to improve teaching and learning in the outpatient setting. The five *microskills* are (a) get a commitment from the learner (about the answer to the problem at hand); (b) probe for supporting evidence; (c) teach general rules; (d) reinforce what was done right; (e) correct mistakes.

The first skill, *get a commitment,* tasks the teacher with making sure the student poses his or her own diagnosis or possible diagnoses as well as an initial plan of care for the patient. *Probe for supporting evidence* asks the instructor to uncover what reasoning underlies the learner's commitment, in essence working to make visible what the student is thinking. The third microskill is *teach general rules*. General rules should be targeted appropriately, limited in scope, and apply to the case at hand. Most importantly, the teaching should also be generalizable to other cases the student might encounter. *Reinforce what was done right* and *correct mistakes* require the teacher to give effective feedback in a timely and productive manner about specific behaviors or reasoning that the student used (Neher & Stevens, 2003).

A small body of literature has evaluated the OMP model since its initial dissemination in 1992. Medical educators viewed the introduction of the OMP as an opportunity for clinical teachers to have the tools to make the teaching process more learner-centered and less focused on patient data and teaching scripts that faculty members would adjust very little based on the needs of the student (Aagaard, Teherani, & Irby, 2004; Irby, 1992). In a large study, which generated two substantive articles about the OMP (Aagaard et al., 2004; Irby, Aagaard, & Teherani, 2004), faculty physicians at seven universities participated in a within-groups study to compare the OMP model and a traditional unstructured teaching model. The faculty members each watched two videos of separate cases: one of a student presenting a case of a pneumothorax to an attending physician and the other of a student presenting a case of gastroespophageal reflux disease (GERD). Each faculty member was randomly assigned to watch one of these cases presented and discussed in the OMP format and the other in the traditional, unstructured format. The faculty members were then asked to evaluate the student's skills and decide upon teaching topics at two time points: once after the student's case presentation and the other after the discussion conducted with the attending physician.

Physicians watching the GERD case were more accurate in diagnosing the patient when observing the OMP model than when watching the traditional model. All physicians rated the

OMP model as a more effective and efficient way of conducting a case presentation and discussion. Interestingly, when observing the OMP model, faculty were more likely to rate student's abilities higher and be more confident in those ratings, a finding that the authors attribute to the OMP allowing student thinking and knowledge to be more visible to the instructor than the traditional model. When prompted to provide a free-response list of topics or points for discussion and teaching after viewing the videos, faculty members viewing the OMP were more likely to teach about generating a differential diagnosis, tests, patient evaluation, and the aspects of how a disease presents than when they viewed the traditional model. Teaching to these aspects of the case is more supportive of learning clinical reasoning than teaching about topics such as presentation skills and history taking skills, the topics highlighted when watching the traditional model.

While offering a robust starting point for discussion of what is useful in a clinical teaching encounter, there are limitations to this study. The study consisted of faculty members observing videos of actors portraying the OMP and traditional teaching models, which does not ensure that the faculty could have executed the OMP themselves had they actually been engaged in the teaching session. Earlier findings substantiate this limitation that carrying out the OMP in the work environment may be more difficult, as students did not rate residents who had been taught to use the OMP in the inpatient setting as more effective teachers than those who had not been taught the model (Furney et al., 2001).

When faculty were asked to highlight teaching topics that they would pursue with the student, there was a wide variety of topics mentioned, alluding to the idea that faculty did not think consistently about what students needed to learn and were not reliable in assessing what students understood or didn't understand. This uncertainty may be mitigated if the faculty themselves were allowed to ask questions as opposed to watching videos of standard questions, however this questioning would also add another unknown variable to the effective execution of the OMP model.

The positive points of this proof of concept work are promising. The structure of the *microskills* involved in the OMP model (in an idealized way, not carried out by the faculty themselves) promoted teaching around clinical reasoning and not general presentation skills. Additionally, it led to more confident ratings of students. Instructors engaged in uncovering what students are thinking have a better ability to notice faulty reasoning or conceptual gaps in knowledge and target those deficiencies (Bransford, Brown, & Cocking, 2000). The hypothesis of student thinking being more visible, however, was not unpacked any further as the crucial part of the OMP model that led to these findings of increased teaching around reasoning and more confidence in rating student performance. If thinking made visible is the crucial difference between the OMP and the traditional teaching model, it needs to be further emphasized or investigated as to how to capitalize on it more effectively to promote clinical learning.

Perhaps the OMP can be condensed into a much more fluid model of teaching if understanding and correcting student thinking is the most important facet of its success. If the final four *microskills* are conceptualized in a dynamic way as being interchangeable with each other, whereby the student expresses reasoning, the instructor immediately corrects faulty reasoning, fills in knowledge gaps, and confirms accurate reasoning steps, the conversation begins to look similar to that of a tutor and tutee attempting to solve a problem together. If all of these *microskills* steps were rolled into one problem solving session between a medical student and his or her attending physician, then much of what is known about the effectiveness of tutoring techniques and strategies from the educational literature should be applicable to this problem solving session in medicine. This theoretical restructuring works to answer the call for a better understanding of *why* and *how* certain aspects of educational techniques work. Additionally, it provides a novel conceptualization of a ubiquitous scenario in medical education, significantly expanding the scope of the literature applicable to the problem at hand.

Clinical Teaching as Tutoring

Conceptualizing the clinical teaching encounter as that of a tutoring dyad allows for the discussion and application of a broad range of work that has been conducted on human tutoring. Fortunately for medical education, much of the clinical learning that medical students and junior physicians participate in naturally occurs where a junior learner is paired with a faculty member who can serve as a tutor. This pedagogical arrangement provides a natural benefit, which Bloom (1984) named the Two Sigma Problem, whereby students who are taught by a human tutor perform two standard deviations above those taught in a traditional classroom. The tutoring structure is inherently present in the clinical environment whereby a learner is presented with a problem (a patient case) and a senior teacher as attending physician serves to help him or her arrive at a diagnosis or management plan. Unlike a more conventional tutoring session, the teacher in a clinical setting is tasked with also discovering the answer to the problem, which may be a difficult undertaking in some circumstances. In the instances where the teacher understands the answer, the discussion of reasoning can proceed as a traditional tutoring encounter might. The truly unknowns, where the tutor does not yet understand the answer, provide a unique venue for the instructor and learner to collaborate on a reasonable solution.

While a review of the large body of work on human tutoring is not in the scope of this paper, a number of studies can provide insight into what is meaningful and promotes learning during a tutoring episode. Additionally, understanding tutoring theoretically aids in guiding thinking about clinical instruction. To assist with an easy understanding of what occurs during human tutoring, the concept of scaffolding will be discussed, followed by a review of some studies of interest in human tutoring and how these findings might be helpful to faculty members hoping to re-conceptualize their clinical teaching.

Scaffolding

Wood, Bruner, & Ross (1976) define scaffolding as a "process that enables a novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts" (p. 90). This is a more theoretically driven and flexible way of understanding clinical teaching than a discrete *microskill* model. Scaffolding can be delineated further as the moves that a given instructor (or tutor) make to generate small problem sub-steps that are more recognizable for the learner. Building on these smaller problem components, a tutor works to uncover what a given learner is thinking (or what his or her hypotheses are about a given problem) and to build to an overall solution. The tutor, therefore, must not only have an understanding of the problem at hand, but also must have an understanding of the tutee, which enables much more personalized problem solving through scaffolding (Wood et al., 1976).

A simple example will clarify these conceptual elements. Suppose a medical student presents a case of a young boy with abdominal pain to an attending physician. The student, a novice in pediatrics, commits to the diagnosis of gastroenteritis, or a viral infection of the intestine. For a variety of clinical reasons, the attending physician believes that the patient might have appendicitis, however, and wants to instruct the student around this clinical reasoning point. Using the OMP model, the instructor would listen to the student's reasoning, and then teach a general rule, whether that be around abdominal pain, appendicitis, or otherwise. Alternatively, if the faculty member scaffolds the student, he or she assists the learner by creating smaller, solvable problems that build to an overall solution. The attending physician might set the stage for thinking and then pose a question: "Let's think anatomically about abdominal pain. The boy's pain is primarily on the right. What structures could be affected?" The faculty member has begun ushering the student to the structure of the appendix, where the student might realize he or she should consider appendicitis or might require further scaffolding. "How do infections of these organs usually present?" This later question is of particular use in scaffolding for clinical reasoning, because it allows for comparing and contrasting of cases, a strategy discussed below.

Scaffolding can be undertaken by using a number of pedagogical strategies to guide problem solving, and the example above illustrates a few general mechanisms for scaffolding to a solution. By setting appropriate sub-problems, instructors can *reduce the degrees of freedom* by simplifying a problem and reducing the number of steps it takes to arrive at a solution. A teacher may do this by asking more knowledge-based questions and then asking the student to reason with that knowledge. Additionally, tutors can serve the purpose of *marking critical features* that are relevant to problem solving. This is especially useful as novices have a tendency to become overwhelmed with irrelevant, superficial details (Bransford et al., 2000). Additionally, if students struggle particularly when it comes to reasoning, tutors can *demonstrate* or model the solution to a task, providing what an ideal solution to an ideal problem might look like (Wood et al., 1976).

Why is Conceptualizing Clinical Teaching as Tutoring Useful?

Conceptualizing tutoring through the lens of scaffolding brings us to the idea that tutoring is *guided learning by doing* (Merrill, Reiser, Merrill, & Landes, 1995). From a professional development perspective, medical students are immersed in supervised workplace training. Ideally, learners should be engaged in the practice of their profession and be challenged by their instructors to assume as much responsibility and autonomy as possible, a preferred characteristic of teachers of outpatient medicine (Irby et al., 1991). Medicine is unique, however, in being described as a tutoring scenario, because legally and ethically, it could not be any other way. Students and young physicians cannot operate independently without guidance and supervision. Tutoring provides benefit for conventional education in that it reduces floundering and subsequent decreases in student confidence (Merrill et al., 1995), and the same is certainly true for medicine. In the clinical environment, however, floundering and failure is not a viable option as the care of patients is at stake. Thus, the role of the clinical tutor can be thought of as guiding the learner by correcting his or her mistakes or errors, the central focus of much scholarship around naturalistic human tutoring.

Thinking of him or herself as a tutor, a clinical teacher can consider how he or she might correct a student who either commits an error or arrives at an impasse in presenting a patient case. This correction, supplementation, or modification in a tutoring episode can be understood through in three ways. Three hypotheses, the student-centered hypothesis, the tutor-centered hypothesis and the interactive hypothesis are explanations as to whom and what is most effective in promoting learning during a tutoring episode. While there is certainly evidence for all three hypotheses in observations of tutoring, the student-centered hypothesis and interactive hypothesis have greater evidence for deep and substantial learning (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001). Factual explanations provided by tutors, as encouraged in the *teach a general rule* step of the OMP, correlate only with a student's shallow learning of material; they do not lead to deeper conceptual learning. Students who construct many of their own explanations and solutions for errors discovered by tutors seem to have better success at deeper learning. Unfortunately, tutors, especially experts in a topic, do not follow a systematic way of progressing through a tutoring session and tend to ignore or are unaware of student misconceptions, often providing long-winded didactic explanations (Chi et al., 2001). Indeed, physicians who are considered experts in a given topic and serve as tutors in a problem-based learning session, where a small group of students collaborates to learn from and solve a problem, have a tendency to usurp conversation and speak more during the session, inhibiting collaborative and student-centered efforts (Silver & Wilkerson, 1991).

In a creative study, Chi et al. (2001) sought to investigate the relative importance of tutor and student contributions as well as the effect of their interaction on student learning. Using the circulatory system as the topic and assessing both shallow learning of facts and deep learning of concepts that require transfer, tutors in a certain condition were instructed to suppress their feedback and explanations, only providing student-directed prompts. The tutors in this condition, without any explanation on how to do so, provided many more and much deeper scaffolding than traditional tutors. Students in this prompting condition were much more constructive during the tutoring session. These students learned just as well, as evidenced on post-session assessments, as the students who received feedback and explanations from tutors, appearing to be slightly *better* at transferring their knowledge of the circulatory system to health-related questions.

Physicians who are engaged in clinical teaching would benefit from the conceptual shift in thought that learning and transfer of knowledge are less focused on what they say but are more so on prompting students to construct their own explanations and collaboratively solve problems. With the tendency for teaching to occur at a single point in time as an explanation from an expert to a novice, teachers ignore the finding that students constructing their own solutions learn more deeply. Teachers of clinical medicine should identify the solution to a problem internally, and instead of communicating that solution as a didactic explanation, they should pose scaffolding prompts (as discussed above) to allow the student to either construct his or her own explanation or collaboratively arrive at a solution. This will be a difficult transition for physicians who are often short on time and are not kind to inefficiencies in their work environment. While didactic explanations may solve the problem of efficiency, they certainly do not solve the problem of being an effective teacher, a failure with potentially worse consequences than waiting times.

The advantages of considering clinical teaching as a tutoring episode, where scaffolding and student construction are more important than explanations by the tutor, also affords medical educators a more promising take on the assessment of medical students. Assessing medical students in the clinical work environment, while still fraught with difficulties, might become a more manageable task with a changed understanding. It is helpful to consider the language used by Irby in his model of inpatient teaching and elaborated upon independently by Chi when describing teachers' task of assessing students (Chi, Siler, & Jeong, 2004; Irby, 1992). Both consider the task of *diagnosis* (of the learner) as uncovering a student's misconceptions, misunderstandings or learning needs, essentially discovering what and how the student understands. This is in contrast to *assessment*, which is the comparison of a student's knowledge to a norm, benchmark, or factual truth. Both are important for teaching, namely in that *diagnosis* is promising in it's ability to bring students to an understanding that would be expected in an *assessment*, however, there are differences in tutors' abilities to perform each of these tasks.

Many attribute the success of the OMP as well as human tutoring to the ability of the teacher to best understand what the student is thinking or generate a *diagnosis* of the student. In a separate analysis of a study by Chi and colleagues cited above (Chi et al., 2004), undergraduate students using traditional tutoring to teach eighth graders about the circulatory system were found to overestimate students' correct beliefs about the system and were poor at understanding students' false beliefs. In other words, their *diagnosis* of what the learner knew or misunderstood was relatively inaccurate and they tended to overestimate what students knew and underestimate what students missed or knew in a flawed way. Alternatively, when it came to *assessment*, or understanding how student's beliefs compared to normative knowledge, tutors were relatively successful, being seventy-two percent accurate, compared with twenty-one percent accurate at *diagnosis*. Tutors who used their time prompting students instead of providing didactic explanations were somewhat better than traditional tutors at uncovering student thinking, and it is hypothesized that they have freed cognitive resources to better make assessments of students' knowledge (Chi et al., 2001).

While seemingly disheartening on the surface in attempting to build an argument around a tutor's ability to understand students' thinking and misunderstandings, there is a silver lining for educators tasked with evaluating students' competency. This evidence that tutors can successfully assess if students know some concept or fact supports the current model of clinical evaluation whereby clinical instructors are responsible for deciding about facets of a given learner's competency. Paired with further faculty development about the context and content specificity of competency, as well as a change from didactic explanations to prompting for student explanations, tutoring is a promising way to increase the fidelity of the competency assessments of learners as provided by clinical faculty.

How Do Tutors Assist Their Students' Learning?

Clinical educators who conceptualize their interaction with learners in the clinical environment as one of a tutoring relationship that benefits from scaffolding will no doubt seek further practical guidance about how to best contribute to their students' learning of clinical reasoning. Given that this relationship is a much more dynamic and fluid one than a stepwise progression of what should happen in a teaching encounter, educators will need more specific guidance about how to scaffold their learners. While there are undoubtedly many ways to scaffold learners, tutors naturally find themselves intervening when they discover an error in a student's work or the student has arrived at an impasse (Merrill et al., 1995). The advantage of this focus is that students discover their errors proximally to when they are committed as opposed to more distally in their problem solving process. This argument, referred to as the *credit assignment problem,* helps novice students pinpoint their errors more quickly and accurately rather than being unable to assign credit to an error once the problem solving process has progressed and the student is unable to identify why he or she arrived at a particular, inaccurate solution.

The idea that visible student thinking about an assessment of a patient allows tutors to intervene immediately when an error is committed might seem contrary to many physicians and students. There is an argument for the practice of permitting a student to speak and explain him or herself without interruption. This is where the delicate balance and judgment of a clinical tutor is crucial. As observed by Merrill (1995) where intelligent undergraduates were being tutored in solving LISP programming problems, the tutors adjusted their intervention when an error occurred based upon how conceptually meaningful the error was. Tutors explicitly corrected low-level errors, those that involved simple, overlooked mistakes. As the errors became increasingly conceptually oriented, tutors tended to flag the error for the student, bringing it to their attention and then allowing the student to own, plan, and advance more of the recovery process. Teachers of clinical medicine must make similar decisions. Should an intervention be surface-level and direct so that subsequent discussion can proceed on the right path, or should the misunderstanding be addressed through scaffolding?

For a clinical tutor, identifying an error and correcting it outright versus flagging it and scaffolding the student to correct the reasoning error promises to occupy a lot of cognitive resource and take nuanced judgment. For example, if a student expresses faulty reasoning about a test result, such as how specific a particular test is for a given disease, the tutor is faced with a difficult decision. He or she could interpret this as a surface-level factual error: “This test is not as specific as you think it is. It actually only has a specificity of 40%.” If he or she expounds upon this slightly, this might be considered teaching a general rule in the diagnosis of a particular disease. No doubt the student will be faced with a similar scenario in the future. Alternatively, the tutor might flag the error by posing a hypothetical scenario in which the test is not as specific: “When I think about *test x*, I think it only has a specificity of 40%. If you adjust for that, how would it change what you think?” In doing this, the tutor has flagged the error, though left the meaning of that error open to interpretation and consideration by the student. This example provides evidence of how conversational feedback assists with the *credit assignment problem* and how scaffolding the student with a strong question of how he or she thinks allows for the student to construct a new solution to the problem, a much more efficacious technique for deep learning than a didactic explanation.

By conceptualizing the clinical teacher’s role as that of a tutor, he or she is provided a much sharper lens through which to view his or her encounter with a clinical student. Instead of a stepwise progression of listening to student reasoning, teaching some general rule and then providing feedback, the idea of tutoring provides the opportunity for a much more interactive dialogue. Clinical teachers can probe, provide feedback and teach with effective scaffolding in a dynamic problem solving session whereby the student is empowered to reach a conclusion on his or her own and assume greater responsibility.

Teaching with Analogical Encoding and Contrasting Cases

Students will not always be able to solve the clinical problem at hand, and there may be many reasons why. They might lack the necessary background knowledge, may not focus on the correct or most important features (as novices tend to do), or might succumb to reasoning biases. In some of these circumstances scaffolding may not be enough to overcome an impasse as the student seeks a diagnosis or plan for a given patient, and the clinical tutor will be called upon to provide more directed instruction. While short didactic topics are efficient and often sufficient to convey a small amount of information to a student, they often do not help a student understand how to focus on the most important features of a problem, or how to organize a large amount of information in a useful way, a critical element of successful clinical reasoning (Bordage, 1994). To achieve each of these goals while providing instruction, clinical teachers should consider capitalizing on analogical encoding by using contrasting cases to assist in filling in the student's knowledge gaps and helping him or her focus on the most important features of a given problem.

Analogical encoding describes the process of learning by drawing comparison across examples and coming to understand a common, deep structure (Gentner, Loewenstein, & Thompson, 2003). Novices tend to focus their attention on common surface features of presenting problems, which often inhibit them from accessing already-acquired knowledge that would be useful in a new situation, essentially a failure of transfer. By engaging learners in uncovering shared relational structures, students can learn to abstract schemas of cases or various illness presentations, a crucial aspect of expertise in medicine (Bordage, 2007; Nendaz & Bordage, 2002).

Contrasting cases provides a mechanism by which clinical tutors can teach medical learners how to reason clinically by utilizing analogical encoding. To help solidify salient points about a given case, posing a contrasting case to the one at hand offers a very practical way to scaffold learners to focus on discriminating features. In comparing cases, students are presented with similar sets of information and contrasts can be made from one set of information to another, allowing students to define their knowledge in a field of similar alternatives (Garner, 1974). The use of contrasting cases examined in juxtaposition increases students' ability to discern specific features that they might otherwise overlook or might not think significant when examining a single example (Barron et al., 1998). Evidence for the utility of this technique is already available in medical education. One study suggests that in using similar standardized cases during a simulation exercise, medical students were only able to focus on important data for decision making once cases were discussed in comparison with an instructor. Students did not attend to the important details when the cases were presented linearly (McMahon, Monaghan, Falchuk, Gordon, & Alexander, 2005).

There is a crucial role for the tutor in the use of contrasting cases; simply asking students to draw comparisons is not as effective as the tutor providing a unifying framework about how to think about the underlying principles (Schwartz & Bransford, 1998). When presented with multiple methods of learning about psychological principles, students who were instructed to contrast cases and then hear an instructor's explanation about the differences learned significantly more than students who summarized reading selections or contrasted cases by themselves. Thus, while utilizing contrasting cases helps students focus their attention on discriminating features, teachers much not assume that novices will notice the important features and be able to explain why they are so (Gentner et al., 2003; Schwartz & Bransford, 1998). The role of the tutor in the clinical setting is to provide the framework to understand the differences between the cases, allowing the students to notice salient features and build their own understanding.

In their argument for a re-conceptualization of transfer as preparation for future learning, Bransford and Schwartz (1999) also posited that contrasting cases is a strong way to contextualize knowledge so that learners are cognitively able to notice important features in the future. The use of contrasts brings attention to the most important and differential points about a given patient presentation and these can be sought after during future encounters. For example, learners may begin to notice different facets of a patient's history or physical exam, focusing their future information gathering on those data points that provide influential information for making a decision. The analysis of contrasting cases also allows students to make better predictions about relevant data (Schwartz & Bransford, 1998), which is an essential component of clinical reasoning: predicting or isolating the illness that is causing a patient's underlying symptoms.

Contrasting cases can be utilized easily in the clinical setting. For example, a clinical teacher, after hearing a student's assessment of a patient with shortness of breath and wheezing found to have reactive airway disease, might offer that the student deliberately unpack what an ideal presentation would look like for asthma. With scaffolding, the student can then be prompted to repeat the exercise for pneumonia, a diagnosis with a potentially similar presentation. In comparing the two presentations side-by-side, the student better sees the discriminating features, such as fever and focality versus diffuse findings on a physical exam. If pressed for time, when assigning reading, a teacher might deliberately ask students to compare and contrast the presentations of two diagnoses at the same time rather than reading about the features of only one illness, and then discuss the differences the following day (Bowen, 2006).

Students will learn to structure their knowledge around the discriminating features of an illness, allowing them to focus on key data points that will help them differentiate various conditions and allow an accurate diagnosis more effectively and efficiently.

Alternatively, to help with both instruction and assessment of a student's understanding of why certain decisions are made, instructors might simply change one important piece of data about a case, essentially generating a contrasting case. For example, a patient presenting to the emergency department with chest pain and shortness of breath may be found to have a heart attack involving the left wall of the heart. The student may present a reasonable management plan consisting of antiplatelet agents, nitroglycerin for symptom control, and a revascularization strategy. While all reasonable and evidence-based, the clinical instructor might change the scenario slightly and ask what or if the student would do anything differently. The faculty member could pose: "Let's say you saw S-T changes in leads II, III and AVF. Would you do anything differently?" This change in the location of the lesion on EKG has a high probability of affecting the right coronary artery the right ventricle, in which case nitroglycerin would be contraindicated and instead aggressive intravenous fluids become essential. By simply changing a single important feature of the presentation, clinical educators can generate a contrasting case and discuss the importance of that discriminating feature on diagnosis and management.

Future Directions

The application of educational theory and empiric research from the learning sciences to medical education has the capacity to revolutionize the way we think about and evaluate teaching medical students and junior physicians in the clinical setting. As in many other professions, change in medical education has been slow and difficult (Bloom, 1988), and there has been very little of it since Abraham Flexner's report in 1910 (Cooke, Irby, & O'Brien, 2010), which built the current model of physician training. The seeds of change have been planted, however, and across the country movements are shifting the way physicians learn, with the hope that a new generation will be able to respond to the needs of our modern society.

Theories built upon empiric work in the learning sciences create an opportunity for this change to be driven by evidence, a crucial tenet of biomedicine and the current paradigm of clinical practice. Since those in medical education struggle to study teaching and learning at such a fine grain as those in more traditional educational settings have been able to, physicians need to begin to pay closer attention to the literature outside of the medical field. Complicated by patient privacy and the complexity of the frequency of activities that could promote learning and transfer, studies of clinical tutoring to demonstrate efficacy of learning in medicine will be difficult to carry out. That does not mean, however, that the theoretical principles investigators of learning have uncovered and tested outside of medicine are not applicable, nor does it mean we should not try and study it ourselves. Translational research in medical education should be considered as similar to that of translational research in clinical medicine. Basic learning science needs to be applied and evaluated in the clinical education setting.

A large-scale study of clinical tutoring might be crafted similarly to Chi et al.'s (2001) study on traditional tutoring compared with a prompting condition. For patient privacy and confidentiality, the patient cases would need to be of standardized patients. Students would take a pre-test focusing on a variety of topics, some important and others as distractors, so as not to isolate student thinking on one type of disease process. Students might then see a patient or panel of patients in a standardized setting, just as they would in the hospital or clinic. Clinical preceptors, also blinded to the cases, would be instructed to teach in one of four ways: (a) without instruction, teaching as they would otherwise; (b) as a prompter: teaching without telling, but only using prompting questions; (c) with a contrasting case: teaching as they would otherwise, but using a contrasting case to the one presented to highlight important features; and (d) with both prompting and contrasting cases: teaching with prompting and inserting a contrasting case, using prompts and scaffolds, to discuss. Students would then take post-test questions, similar to those on the pre-test, to evaluate for learning outcomes. Learning could be measured (via change from pre-post, success on certain questions that require transfer, etc.) and conversations could be coded to see how tutors actually taught and how this affected student learning.

This is an example of the kind of work that would help us in medical education answer *why* and *how* certain formats of clinical teaching work. Guided by evidence from other fields and driven by substantiated theories, clinical educators should seek to better understand their role as teachers as tirelessly as they do in their vocation as physicians.

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