Medical Teacher

ISSN: 0142-159X (Print) 1466-187X (Online) Journal homepage: https://www.tandfonline.com/loi/imte20

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To cite this article: Maria Mylopoulos, Naomi Steenhof, Amit Kaushal & Nicole N. Woods (2018) Twelve tips for designing curricula that support the development of adaptive expertise, Medical Teacher, 40:8, 850-854, DOI: 10.1080/0142159X.2018.1484082

To link to this article: https://doi.org/10.1080/0142159X.2018.1484082

Published online: 15 Jul 2018.

MEDICAL TEACHER
2018, VOL. 40, NO. 8, 850–854
https://doi.org/10.1080/0142159X.2018.1484082

MEDICAL TEACHER

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TWELVE TIPS

Twelve tips for designing curricula that support the development of adaptive expertise

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ABSTRACT

An essential component of expertise is a clinician's ability to adapt to uncertain, complex, or novel situations while maintaining their competence in routine situations. Adaptive expertise provides a framework for understanding and developing experts who have the skills to effectively balance and support these dimensions of work using both procedural and conceptual knowledge. It is important for educators to understand that often the training which fosters adaptive expertise does not require new tools or approaches, but rather a reconceptualization of training using many of the same instruction and assessment formats already available. The twelve tips discussed in this paper showcase ways in which education can be transformed to support the development of adaptive expertise including the significance of instruction that combines various forms for knowledge, the value of productive struggle, and shifting the design of assessments to support learning and performance beyond retention and direct application.

Introduction

The need for clinicians to be able to adapt to uncertain, complex, or novel situations while maintaining their effectiveness and efficiency in routine situations has become even more relevant in a climate of increasingly limited resources and escalating patient complexity. Adaptive expertise offers a framework for understanding and developing experts who are able to appropriately balance these two dimensions of work. Like in most frameworks of expertise, the acquisition of domain specific knowledge is at the core of adaptive expertise. Critically however, alongside procedural knowledge (i.e. knowing "what"), adaptive expertise requires acquisition of conceptual knowledge (i.e. knowing "why"), to support both the procedural application of known solutions as well as the use of acquired knowledge as a foundation to generate new solutions. Given that medical education has traditionally emphasized the acquisition of knowledge primarily for application and procedural efficiency, the current imperative for educators is to understand how instruction and assessment must be transformed to support the development of both dimensions of adaptive expertise. This paper will offer 12 tips for supporting the development of adaptive expertise including the importance of instruction that integrates different forms of knowledge, the value of productive struggle and exposure to meaningful variation, and the design of assessments that make visible the development of both procedural and conceptual knowledge.

Tip 1

Understand that you are not producing experts, but rather preparing future experts

Medical education is often premised on the assumption that the primary goal of training is to provide students with the knowledge, skills, and attitudes needed for independent practice. Not surprisingly therefore, most current models of instruction and assessment emphasize the acquisition of procedural knowledge and demonstration of procedural efficiency aimed at determining whether trainees are experts by the end of training. Training aimed at development of adaptive expertise demands that alongside procedural efficiency, learners must also be prepared to problem-solve in situations they have never encountered. This type of problem-solving requires conceptual knowledge that supports "preparation for future learning" (PFL), the ability to learn new information, make effective use of resources, and invent new procedures in order to support learning and problem solving in practice (Schwartz et al. 2005; Mylopoulos et al. 2016). Cycles of instruction and assessment that support development of both procedural efficiency and PFL are therefore the focus of training for adaptive expertise. This aim is more achievable than it may at first seem, because when instructional design is aimed at the acquisition of conceptual knowledge (see tips 2 through 12) students perform well on assessments of *both* procedural efficiency and PFL (Schwartz et al. 2005; Kapur 2014; Mylopoulos and Woods 2014). Therefore, educators are not forced to make a choice between training for the different dimensions of adaptive expertise. Rather, they can train simultaneously for both with the same instruction and assessment designs.

Tip 2

Avoid cycles of instruction and assessment that reward only short-term performance

The inclusion of PFL as a guiding principle of curricula requires that long-term learning be an explicit goal of training. Maximizing only short-term performance by emphasizing knowledge acquisition and assessment is

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insufficient for long-term learning. A classic example of this form of training is didactic instruction that focuses on learners acquiring facts, e.g. "brain stem stroke causes diplopia," and then assessing the retention and perhaps direct application of those facts, e.g. "What is a cause of diplopia?" or "Describe an appropriate treatment plan for this patient with diplopia." Students will typically perform well on these cycles of instruction and assessment; however, this short-term success has been shown to be insufficient for supporting long-term learning (Schwartz and Martin 2004; Kapur 2014). More insidiously, instructional design aimed at PFL may only enhance performance on long-term learning, not benefit students on short-term performance. This may result in educators doubting the value of the instruction (Schwartz and Bransford 1998; Mylopoulos and Woods 2014). Therefore, it is critical that educators not overemphasize short-term success as a measure of educational effectiveness.

Tip 3

Cultivate long-term learning

Instruction can be designed to maximize both short-term success and long-term learning. When this is done correctly, learners are supported to be successful in their immediate problem-solving as well as acquire conceptual knowledge that supports later learning. Commonly used pedagogical models like problem-based learning (PBL) or case-based learning (CBL) can support both short-term success and long-term learning by scaffolding students to successfully problem-solve through discovery and exploration while guiding them sufficiently to ensure attention to key learning objectives (Kapur 2016). If done this way, PBL and CBL support both immediate success as well as development of conceptual knowledge that can serve as the foundation for later learning. While these types of collaborative, active learning models continue to be widely used in medical education, even didactic instruction can support both short-term success and long-term learning, as long as the instruction provided supports cognitive integration (Mylopoulos and Woods 2014).

Tip 4

Design instruction in the classroom to support cognitive integration

Recent research has demonstrated the positive impact of integration of clinical and basic sciences (Kulasegaram et al. 2015). The deep conceptual knowledge developed through integrated instruction is key for fostering adaptive expertise as it enables learners to deal with complexity (difficult cases, science is fundamental) and better prepares them for new learning of related content (PFL). The development of programs and courses that integrate basic and clinical sciences is common in many medical schools. However, integration at the level of the individual teaching session is often ignored (Kulasegaram et al. 2013). Although the integration of basic and clinical sciences must be supported through the overall curricular structure, *cognitive integration* of these two forms of knowledge within the mind of the learner is achieved through intervention at the level of individual teaching sessions. Cognitive integration requires instructional materials and learning experiences (e.g. lecture slides and bedside discussions) that explicitly link clinical manifestations with underlying basic science mechanisms. Teachers must ensure that basic and clinical sciences are not simply taught at the same time. For example, a statement like "nerves which control the eyeball muscles arise in the brainstem" followed by "brain stem strokes cause diplopia" is an example of "proximate instruction," that is basic and clinical science stated in proximity of one another with no explicit links between them. Instead, learning opportunities should be carefully constructed to teach explicit connections between basic and clinical science (Baghdady et al. 2013; Kulasegaram, Min, et al. 2015). For example, "nerves which control the eyeball muscles arise in the brainstem and loss of their function leads to diplopia" is an illustration of "integrated instruction." Ideally, integrated instruction should help learners understand why certain signs and symptoms occur and encourage the development of a tightly woven mental model of clinical and basic science content as the foundation on which new knowledge can be built.

Tip 5

Understand that any form of mechanistic knowledge can be integrated

Coherent mental models and rich conceptual knowledge are the basis of adaptive expertise. Although medical education frequently emphasizes integration of biomedical sciences such as biochemistry and anatomy, virtually any form of knowledge that provides an explanatory connection for clinical content can be useful in the development of adaptive expertise. The expert physician must be able to integrate their knowledge of clinical signs and symptoms with understanding of patient values, social context, and available resources in order to meet the needs of patients and society. Expert knowledge therefore encompasses traditionally defined clinical and basic science knowledge as well as understanding of the circumstances specific to the practice setting and the individual patient's needs (Lucey 2013). Utilizing the same principles of cognitive integration that apply to integrated instruction of biochemistry and anatomy, educators can help students develop mental models that include explanatory mechanisms from the social, behavioral, and systems sciences. A robust mental model, including causal connections from variety of sources, will better prepare students to make decisions in the face of complexity and generate new solutions to meet patient needs.

Tip 6

Ask "why" questions to reinforce cognitive integration and support conceptual knowledge development

Instructional design for cognitive integration can be made easier by implementing approaches to education that consistently prompt students to ask and answer "why" questions. The most useful mechanistic connections are ones that explain *why*. The reason why a patient is presenting with a specific cluster of symptoms creates meaningful connections to underlying biological mechanisms. The answer to why a particular treatment is the best option for a specific patient might involve a systems or social determinants of health mechanism. By asking themselves "why" and embedding explicit reference to underlying connections and explanatory mechanisms in formal instructional materials such as lecture slides and clinical case scenarios, teachers can provide the basic foundations of cognitive integration regardless of the pedagogical format. Teachers can continue to support the development of deeper conceptual knowledge by prompting students with why questions in formal assessments, at the bedside or informal conversations. These types of questions, even when they are answered incorrectly, shift the emphasis from surface understanding to the deeper connective elements between concepts, cementing the cognitive structures needed for future learning.

Tip 7

Allow students to struggle and sometimes fail

Allowing learners to struggle is a powerful strategy that supports the development of adaptive expertise. When learners are encouraged to struggle with complex problems, they may not generate a solution in the short term; however, the struggle may activate relevant prior knowledge which can improve conceptual understanding and support later learning. Though generating an answer can create more difficulty in the short term (when compared to presenting the solution directly to the learner), it tends to lead to more durable and flexible learning (Bjork and Bjork 2014). When learners strive to generate solutions, they (a) understand the problem better, (b) think about how they were trying to solve the problem, (c) assess the limits of their solution, and (d) consolidate their knowledge into the conventional solution when it is presented to them (Schwartz et al. 2009; Bjork and Bjork 2014; Kapur 2014). Struggle, invention, and even failure are crucial, if the goal is to develop deeper conceptual understanding and help learners build a foundation to use the acquired knowledge to generate new solutions.

Tip 8

Give immediate direct instruction or feedback to ensure struggle is productive

Although engaging students in struggle can enhance their conceptual knowledge, it can also result in failed learning opportunities and perpetuate misconceptions (Sweller 2009). It is important that students still achieve specific learning objectives and are introduced to established approaches to solving a problem. One way to do this is to create a time for direct instruction or feedback after providing an opportunity for struggle. Immediate feedback can be used to orient students toward important principles, highlight salient features, introduce prompting questions, reinforce performance, and correct conceptual errors. It also offers teachers a chance to dig deeper and identify the limits of learners' current understanding, making the struggle fruitful (Kapur 2014). Providing immediate feedback thus creates an opportunity for students to improve their understanding of key concepts. Direct instruction can be offered in lectures, small group discussions, or one-on-one. It is an opportunity to review general principles, to deconstruct clinical concepts and their mechanisms, and to highlight areas of difficulty after students have experienced the difficulty for themselves (Schwartz and Bransford 1998). Using direct instruction to complement struggle ensures that the struggle is productive and enhances conceptual understanding.

Tip 9

Expose students to meaningful variation

Building conceptual knowledge requires that students develop deep understanding of clinical concepts. One of the most powerful ways to showcase different dimensions of a clinical concept is giving a number of varying examples that "represent the range of ways in which specific conditions present" (Eva et al. 1998). However, while this approach has value for developing a database of examples that can support sophisticated analogical reasoning (or knowing "what" in as many situations as possible), variation that supports development of conceptual knowledge requires a slightly different approach. Students must be tasked with understanding the implications of the variation on the concept being presented. That is the variation must support meaningful understanding of the concept, rather than simply providing a repository of examples to draw from in future problem-solving. For example, when students are presented a series of cases, they may be asked to "invent a general explanation" that would account for all the variability they are seeing (Schwartz et al. 2011). In doing so, students are oriented to attend to the relationships between variables, pushing them toward mechanistic understanding of the concept they are learning.

Tip 10

Ask "what if" questions to make variation meaningful

Another powerful way to make variation meaningful for students is to ask students "what if" questions chosen carefully to emphasize the features of a clinical concept students should attend to. This technique can be used effectively in assessments, and both classroom based and bedside teaching. For example, in a CBL setting, teachers should first clarify for themselves the core clinical concept they intend to teach using the case. Once students are familiar with the case, teachers can make the core concept visible by strategically asking "what if" questions that vary surface presentation. These variations in aspects of the case like patient history, lab results, demographics, etc. must reinforce key elements of the core concept and push students to extend their understanding of underlying mechanisms of the clinical concept.

Tip 11

Assess frequently and formatively to gauge student understanding and provide feedback

Assessment can be used to give students an opportunity to practice and explore prototypical and challenging cases in a low-stakes environment (Kulasegaram and Rangachari 2018). When used this way, assessment drives learning and can expose areas of strength and weakness. However, while assessments of learning are typical and aimed at telling a student whether they are right or wrong, assessments for learning are also useful for the development of adaptive expertise. Formative and frequent assessments create opportunities to explore understanding, highlight nuances of a concept, and provide ongoing feedback (Kulasegaram and Rangachari 2018). For example, a formative assessment item in which a student is asked to make a therapeutic decision and justify his/her choice – correct or otherwise – before being offered feedback might emphasize the mechanisms that underpin a clinical concept. In this way, formative assessment can enhance the learning opportunity for the student by promoting deeper understanding and the development of conceptual knowledge.

Tip 12

Align instruction and assessment

It is imperative to align systems of instruction and assessment. Standard assessments that emphasize replication and application of knowledge will not make visible the advantage held by students who are taught using strategies that support development of adaptive expertise. This can make it appear as if the time spent carefully designing integrated instruction, productive struggle, and meaningful variation was wasted. However, the benefits of these forms of instruction are made visible when assessments are also aligned with the goals of adaptive expertise. For example, as part of a program of assessment, instructors can include PFL assessments that measure students' performance on novel problems requiring new learning at the time of assessment. Alongside other assessments that capture the impact of integrated instruction and meaningful variation, a PFL assessment allows teachers to gauge students' ability to learn and apply new related content during problem-solving, which is a central aim of training for adaptive expertise.

Conclusions

These 12 tips showcase the ways in which education can be transformed to support development of adaptive expertise. While traditional models of medical education have supported the development of the procedural knowledge for efficient problem-solving, adaptive expertise additionally requires development of conceptual knowledge to support later learning and innovation. These complementary dimensions of expertise must both be developed from the beginning of training. Critically, training that fosters both dimensions of adaptive expertise does not necessarily require new tools and approaches, but rather a reorientation to education using many of the same instruction and assessment formats already available. Didactic instruction can be transformed into integrated instruction; PBL can be used to maximize productive struggle; assessments can be shifted to support learning by adjusting frequency and supporting performance beyond retention and direct application. These are often small tweaks that can nonetheless have a significant impact on the development of adaptive expertise.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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