MIND, BRAIN, AND EDUCATION

A Mental Model of the Learner: Teaching the Basic Science of Educational Psychology to Future Teachers

Daniel T. Willingham[1]

ABSTRACT— Although most teacher education programs include instruction in the basic science of psychology, practicing teachers report that this preparation has low utility. Researchers have considered what sort of information from psychology about children's thinking, emotion, and motivation would be useful for teachers' practice. Here, I take a different tack. I begin by considering three varieties of statements in basic science: empirical observations, theoretical statements, and epistemic assumptions. I suggest that the first of these can support classroom application, but the latter two cannot. I use that conclusion as a starting point for considering the instruction of prospective teachers in psychology.

Educational psychology represents a big tent of ideas (Calfee, 1981; Gage, 1978; O'Donnell & Levin, 2001; Phillips, 1996), but the goal and methods of the field include a through line that extends back to Thorndike (1910). Findings from psychology can inspire new methods, and researchers can use scientific methods to evaluate the relative effectiveness of methods, however they were inspired.

But researchers have argued that teachers' learning should not be limited to practical classroom strategies (Berliner, 2001; Eraut, 1994). The teacher who understands the psychological principles undergirding the recommended strategies will presumably find them more sensible and will see ties between seemingly disparate strategies. Perhaps most important, that teacher will also generalize strategies to novel situations (L. M. Anderson et al., 1995; Patrick, Anderman, Bruening, & Duffin, 2011; Shuell, 1996). Teachers need what might be called a mental model of the learner: knowledge of children's cognitive, emotional, and motivational makeup.

Most programs at schools of education require some study of educational psychology (Berliner, 1993), but teachers retrospectively describe their education as overly theoretical, difficult to grasp, and ultimately of low utility (Berliner, 1992; Hobson, 2003; Kiewra & Gubbels, 1997). This problem drew close attention from researchers in the early 1990s, following experimental work indicating that knowledge acquired in one setting often transfers poorly to another setting (Gick & Holyoak, 1983) and theoretical work suggesting that knowledge might remain embedded in the learning situation (Lave & Wenger, 1991). Why, then, should one expect that a teacher will successfully transfer decontextualized knowledge about children's cognition, emotion, and motivation acquired from a textbook to a teaching situation in a classroom months or years later?

A committee created by the Educational Psychology Division of the American Psychological Association published something of a call to arms for the field to address the problem (L. M. Anderson et al., 1995), and writers of educational psychology textbooks responded by taking greater care to illustrate psychological abstractions with classroom examples and by including more classroom scenarios that offered readers practice in using the principles (Patrick et al., 2011). Based on our understanding of transfer, there is every reason to believe that these steps were helpful. Yet they seem not to have been sufficient. A recent national survey of teachers showed that their top complaint about their education was an overemphasis on theory (American Federation of Teachers Teacher Preparation Task Force, 2012).

[1]Department of Psychology, University of Virginia

Address correspondence to Daniel T. Willingham, Department of Psychology, University of Virginia, Box 400400, Charlottesville, VA 22904; e-mail: willingham@virginia.edu

How can we ensure that teachers have useful knowledge about children? When considering the problem of transfer, much attention has been focused on types of knowledge. For example, Korthagen and Kessels (1999) distinguished between *episteme* (broad general principles) and *phronesis* (situation-specific knowledge). Bereiter (2014) called for an emphasis on what he calls principled practical knowledge, which would have characteristics of both theory and practical know-how. Shulman (1987) differentiated between seven types of teacher knowledge, the two best known and most studied being content knowledge and pedagogical content knowledge. In each case, the researcher considers what knowledge the teacher ought to have and what purpose it might serve.

Here, I take a different tack. Rather than considering varieties of teacher knowledge, I consider the claims from basic science that teachers might be asked to learn, differentiating among them by the roles that these claims play in the scientific process and then considering the extent to which they can support applications to practice. I differentiate among empirical observations, theoretical statements, and epistemic assumptions. I argue that neither theory nor epistemic assumptions as they are used in scientific practice can support classroom application, whereas a particular type of empirical observation can.

WHAT SHOULD GO INTO THE TEACHER'S MENTAL MODEL OF THE LEARNER?

If teachers are to study psychology in the hopes of better understanding children's processes of cognition, motivation, and emotion, we need to specify what findings from the science of psychology teachers ought to learn.

Characterizing empirical observations, theoretical statements, epistemic assumptions, and the relationships among them are central topics in the philosophy of science, and the professional literature addressing them is enormous (see, e.g., Curd, Cover, & Pincock, 2012). For the purposes of this article, simple definitions will do, as our concern is not to defend a normative or descriptive version of science, but to acknowledge the differences among these sorts of statements and then to consider whether they differ in their usefulness to teachers. In addition, psychologists differ in what they consider appropriate empirical observations or theoretical statements, depending on the epistemic assumptions they make. Rather than qualifying and hedging throughout this article, I write from the cognitive point of view regarding epistemology (von Neumann, 1958), but maintain that the argument and conclusions apply to other perspectives on psychology, including behaviorist (Sechenov, 1935; Watson, 1913) or sociocultural views of thought (Vygotsky, 1978).

Empirical observations will refer to empirically observed, reproducible phenomena, that is, observations that are a product of research. For example, the term *observations* might include that people can maintain only a limited amount of information in mind at once (Miller, 1956), that this information is forgotten after a delay of less than a minute (Peterson & Peterson, 1959), and that differences among individuals in this capacity are associated with differences in some skills relevant to classrooms, such as reading comprehension (Daneman & Carpenter, 1980). *Theories* will refer to groups of related statements that organize, unify, and, perhaps, explain a set of observations. Examples would include the working memory models of Baddeley (2012), Cowan (1999), and Ericsson and Kintsch (1995). *Epistemic assumptions* will refer to assumptions about the nature of knowledge and the conduct of psychological science. For example, the working memory theories mentioned assume that knowledge may fruitfully be described in terms of mental symbols and processes that operate on those symbols (McCulloch & Pitts, 1943; Putnam, 1960).

Empirical observations, theoretical statements, and epistemic assumptions relate to one another, of course. Here, I focus on the fact that because theories are meant to account for observations, observations constrain theories (Bacon, 2000), but many theories can account for the same set of observations (Duhem, 1954) It will also be relevant that creating a theory is not possible in the absence of epistemic assumptions; thus, assumptions also constrain theories (Quine, 1951).

But it is also true that observations are inevitably colored by theories and that theories influence the sorts of observations one makes (Hanson, 1958). Likewise, epistemic assumptions can also be influenced by theories, especially the success or failure of many theories over time (Kuhn, 1962). That would seem to jeopardize from the start the distinction I am making. I have said that scientific observational statements have utility for teachers, but theoretical statements and epistemic assumptions do not, yet the first type of statement is imbued with the other two types. I will return to this problem, but first consider each type of statement separately.

Empirical Generalizations

It seems self-evident that teachers ought to be interested in scientifically based observations of children. After all, if the aim is to develop a useful mental model of what children are like, then what children typically do would seem not just relevant, but essential. Yet it is equally obvious that there must be some constraints on which observations are worth learning, given that hundreds of thousands of potentially relevant empirical experiments are published each year.

The practice of science offers a useful analogy to this problem. Consider the scientist developing a theory to account for existing observations in a domain—skill acquisition, say, or language learning. The researcher must choose which observations are so important that the theory simply must account for them. Many observations can be considered tentative because they have yet to be replicated or perhaps are related to, but not central to, the domain. So researchers pay close attention to those observations they think are sufficiently reliable across individuals and contexts and that seem to capture an important aspect of the domain. I call such observations *empirical generalizations*. I suggest that sort of observation is a good candidate for something a teacher should know.

Of course, appealing to characteristics such as "sufficiently reliable" and "important" implies some subjectivity in determining whether a finding merits the label, but subjectivity does not mean that these features are meaningless. A similar criterion has long been used by philosophers considering what makes a theory scientific. For example, Popper (1963) emphasized falsifiability as a crucial criterion of the demarcation of science. An implication is that theories gain no scientific credit by predicting what everyone already knows. For example, a theorist cannot claim that his theory is falsifiable because it predicts a negatively accelerating learning curve, conduct an experiment, and then seek plaudits when the prediction is confirmed; it is well known that learning curves are virtually *always* negatively accelerating.

This sort of finding is, I suggest, exactly what teachers ought to know: the aspects of learning (and attention, emotion, and so on) that researchers consider well established and perfectly obvious. Other examples of empirical generalization bearing on learning might include such observations as that practice is crucial to gaining expertise (Ericsson, Charness, Feltovich, & Hoffman, 2006), that probing memory improves retention (Agarwal, Bain, & Chamberlain, 2012), that memory for specific episodes can be conflated with memory of generic episodes (Bartlett, 1932), that sleep improves memory (M. P. Walker, 2012), that only the attended aspect of an experience will be learned (Morris, Bransford, & Franks, 1977), and that memory for context is more fragile than memory for content (Johnson, Hashtroudi, & Lindsay, 1993).

We should add the obvious caveat that if a teacher is to learn an empirical generalization, it must carry some promise of implication for practice. For example, an empirical generalization from learning theory is that subjects can identify a relatively large number of stimuli (20 or more) after very brief exposure (50 ms), but forgetting of this information is very rapid (2 s or so). This phenomenon is quite reliable (Long, 1980), seems to capture an important aspect of human cognition, and so appears in most introductory cognition textbooks (e.g., Matlin, 2012; Reisberg, 2015). But the phenomenon is of no consequence to education, and so it would be a poor candidate for an empirical generalization that teachers ought to know.

Still other empirical generalizations might carry relevant applications for classrooms, but the applications are associated with small effect sizes. For example, human memory does seem to depend, to some extent, on emotional state: memories encoded when one is happy are easier to later retrieve if one feels happy rather than sad. But the effect size of this memory phenomenon is modest—around $d = 0.12$—so it is doubtful that it would be worth teachers' attention (Ucros, 1989).

It might be objected that "what's known" is, at best, a moving target. After all, at one time, it was "known" that the Sun circled the Earth; what we think we know is subject to change. That is of course true, but that is the nature of science. If our criterion of surety is "will never change," that is tantamount to removing educational psychology from teacher education.

Theories

It might seem obvious that teachers ought to learn psychological theories. After all, the goal is that they have a mental model of the learner and that model must presumably be an abstraction, a representation of general tendencies. Isn't that more or less a theory of behavior? For example, if I want teachers to bear in mind, say, five empirical generalizations about working memory, why not ask them to study Baddeley's (2012) theory of working memory, which captures all five and more?

A problem is that theories generate untested, and therefore possibly misleading, predictions. As noted, a theory would be viewed as weak if it accounted for existing empirical generalizations but generated no new predictions. Thus, by asking teachers to learn psychological theory, we would ask them to create a mental model that probably makes some inaccurate predictions. For example, the original working memory model predicted that auditory and visual information could not interact in working memory unless the central executive orchestrated the interaction (Baddeley & Hitch, 1974). That prediction had not been tested when the model was proposed, but was later shown not to be true (Chincotta, Underwood, Ghani, Papadopoulou, & Wresinski, 1999). More directly relevant to education, many predictions derived from Piaget's model of cognitive development (Piaget, 1952, 1954) turned out to underestimate the cognition children are capable of (Baillargeon, 2004; Gelman, 1983).

If empirical generalizations are subject to change, theories are downright evanescent. The best a scientist can hope for is that his or her theory will remain largely intact for some time. Curiously, the theories in educational psychology that are

most often presented more or less intact to teachers—those of Piaget, Vygotsky, and Erikson—are already known to need significant qualification, and little wonder, given that decades of further work has informed developmental psychology since the death of each of these researchers. Certainly, their influence is monumental, but it is perhaps more important for researchers to recognize that influence than it is for teachers to do so. It is not obvious why it is useful to their practice for teachers to learn a theory *and* to learn why we know the theory to be incomplete.

Thus, statements about children derived from theories have the potential to mislead practitioners because at least some predictions are untested. But this is a characteristic of theories as researchers devise them. Later, I will propose that a different type of theory could prove useful to future teachers—a theory that helps integrate empirical observations and motivate why they are true, but does not generate untested predictions.

First, however, we consider epistemic assumptions. It may seem obvious that there is little point in emphasizing epistemic assumptions in teacher education, exactly because they are assumptions. A greater problem, however, is their lack of specificity.

Epistemic Assumptions

It is not possible to generate scientific theory without making assumptions. In psychology, the assumptions often concern the nature of knowledge and how science should be practiced. For example, most educational psychology textbooks differentiate among three broad approaches to psychological theory—behaviorism, information processing, and constructivism—which differ in their assumptions about how knowledge and learning ought to be viewed. Behaviorists operationalize abstract concepts—for example, "hunger" or "learning"—as observable behaviors, and knowledge is characterized as relationships among observable events (Watson, 1913). Psychologists adopting an information processing perspective characterize knowledge as mental symbols and processes and learning as a change in these symbols, processes, or both (Newell, Shaw, & Simon, 1958; von Neumann, 1958). Within constructivism, advocates of the situated cognition view characterize knowledge as embedded in social contexts and in the concrete situations where learning occurs (Greeno, 1989; Lave & Wenger, 1991).

Just as many theories can account for the same set of empirical generalizations, many theories can also be consistent with a given set of epistemic assumptions. That is, Guthrie, Hull, and Thorndike may all fairly be described as behaviorists, but there are substantive differences in each researcher's theory (for an overview, see Hilgard & Bower, 1975). This diversity is possible because epistemic assumptions place rather loose constraints on theory. Indeed, that is why it is difficult to adjudicate among different sets of epistemic assumptions and why, despite much heated interchange in the late 1990s, it remains unclear whether constructivism or information processing offers more promise (J. R. Anderson, Reder, & Simon, 1997). This is not to say that epistemic assumptions are never abandoned. Individual scientists switch allegiances when they think the weight of evidence makes other assumptions more sensible, and trends in the field—the "cognitive revolution," for example—are created when a significant proportion of researchers turn the same way in a short period of time (Kuhn, 1962).

A problem, then, is that epistemic assumptions are too general to bear the weight of implications for practice. Consider a statement like "learning is social." What does that statement actually predict about behavior and imply for teaching practice? That statement might be taken to mean that because humans are social beings, learning opportunities are influenced by what others around us do. For example, if a child's peers are uninterested in learning, that reduces the child's motivation and also means that the child is surrounded by students asking fewer questions. In this sense, learning is influenced by social factors, but remains the act of an individual. Alternatively, "learning is social" might be interpreted as suggesting that social interaction is more intrinsic to learning. One might suggest that because new learning happens in the context of what we already know, all learning is filtered through our self-image. And because self-image is socially constructed, all learning is social. In this view, learning is not merely influenced by social factors; learning is intrinsically (if indirectly) social. A third possibility is that learning is *entirely* social. It makes no sense to describe learning in terms of symbols and processes inside the head of an individual; that would be a categorical error. Learning must be considered as a web of connections among individuals and aspects of the physical environment.

Epistemic assumptions may be general, but they can *sound* like empirical generalizations, and therein lies the problem. A statement like "learning is social" could be taken to mean "children learn best in social situations," which is actually a very different statement—it is a statement about how children behave. But confusing it with "learning is social" could easily lead to thinking that because group discussion is more social than teacher instruction, it is a settled matter that it is more effective for learning, whereas the empirical reality is more complicated (e.g., Pai, Sears, & Maeda, 2015). In the same way, if an epistemic assumption like "learning is situated" is mistaken as a generalization based on the experimental data, it is easy to see why someone would erroneously assume that research has concluded that apprenticeships or authentic tasks lead to better outcomes than the learning of more abstract knowledge in didactic classrooms; again, the research is more complex (Sadler, Burgin, McKinney, & Ponjuan, 2010).

INTERACTIONS AMONG LEVELS

I have suggested that empirical generalizations form the backbone of teacher education and that there is little benefit and some cost to asking prospective teachers to learn theories and epistemic assumptions. The problem with this position is, as noted, that empirical generalizations inevitably have theoretical and epistemic positions embedded in them. For example, I suggested "practice is crucial to gaining expertise" as an empirical generalization, but different theorists would offer different characterizations of "practice," and in the case of researchers making different epistemic assumptions, the differences could be enormous.

So theory and epistemic assumptions cannot be banished from teacher education. In truth, there is a decided benefit to learning theory. By offering hypothetical mechanisms explaining why empirical generalizations happen, theories make them more meaningful, and they build connections among them. That is a much easier way to learn a set of empirical generalizations (Tulving, 1962). But the theory and epistemic assumptions future teachers encounter should be designed for and useful to practitioners, not researchers.

Practitioners Need One Theory

It is the nature of science that theories and sets of epistemic assumptions compete; that is, they offer different accounts of the same empirical generalizations. For example, learning typically transfers poorly to new contexts (Proctor & Dutta, 1995). Cognitive accounts typically suggest that occurs because the long-term memory representation cannot be accessed (J. R. Anderson & Singley, 1989). Some constructivists suggest that the learning context is intrinsic to the memory representation; it makes no sense to talk about the learning as being entirely contained within the learners' mind (Greeno, 1997). Behaviorists invoke the idea of generalization, with its focus on the overlap between the old and new environments (Woodworth & Thorndike, 1901). Educational psychology textbooks do not choose among behaviorist, information processing, and constructivist perspectives on transfer. They offer readers all three accounts.

There are two reasons instructors of prospective teachers might think it is useful for future teachers to encounter different ways of conceptualizing the same phenomenon. First, as a matter of intellectual integrity, describing the different accounts accurately reflects the state of the field; not all psychologists agree on which is best. Second, there is the issue of application. Multiple perspectives might allow teachers to adopt whichever stance offers the best fit to their emerging teaching style. Or perhaps they will use these different conceptualizations of learning in different circumstances.

But there are significant drawbacks to presenting different accounts for the same phenomenon. One is the simple memory load for prospective teachers—they may be overwhelmed by detail and retain very little (Anderman & Leake, 2005). Another is the probability that explanations will not simply differ, but will contradict one another. For example, from the behaviorist's point of view, rewards should increase the probability of behavior, and this increase should be maintainable upon their withdrawal (Cameron, Banko, & Pierce, 2001). From a cognitive point of view, however, the consequences of reward on behavior depend heavily on how the student construes the reward. Furthermore, any increase in the rewarded behavior is predicted to fall to baseline levels (or below) when the reward is withdrawn (Deci, Ryan, & Koestner, 1999).

It would be natural for a teacher candidate to view these conflicting viewpoints as options from which she might choose: the behaviorists have their view of motivation, and humanists have theirs. Each point of view is associated with classroom tools: the behaviorist-inspired token economy (Kazdin & Bootzin, 1972), for example, or the humanist's emphasis on autonomy and control (d'Ailly, 2003). If the teacher concludes that she can select the tool that best fits his or her practice and the situation, it is likely that he or she will select the tool that best aligns with his or her existing beliefs (Gilovich & Griffin, 2010).

This pick-a-tool approach is selective in characterizing the classroom. The teacher who focuses on autonomy still has a classroom of students who respond to reinforcements, just as the teacher who implements the token economy still has students who respond to autonomy. The notion that teachers can select the best-fit theoretical stance invites them to remember the empirical generalizations that fit that stance best and neglect the others.

A solution would be to teach all empirical generalizations as equally important, but do so in the context of just one theory, derived from one epistemology. Do not teach prospective teachers behaviorism and information processing and constructivism. It is important to know all three perspectives if you are a researcher. It is not if you are a teacher. The purpose of a psychological model for a teacher is different than that for a researcher. Teachers do not need an introduction to the broad intellectual trends in the discipline. They need a way to understand, coordinate, and remember empirical generalizations. Ideally, prospective teachers would learn a single theory that captures all empirical generalizations, rather than a collection of models, each of which highlights a subset of empirical generalizations, but is not applicable to others.

This claim obviously invites the question "Which theory?"

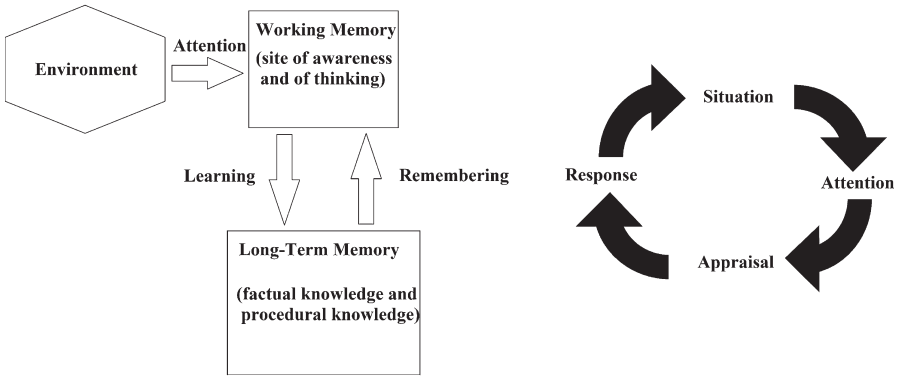

Fig. 1. Two examples of modal models. At left, a model of cognitive processes (Willingham, 2009), and at right, a model of emotion (Gross, 2015).

Practitioners Need a Theory That Would Bore Researchers

Theory is unavoidable, but does have the drawback mentioned earlier—theories make untested (and likely, inaccurate) predictions, which invite ineffective classroom applications. The problem might be solved by teaching empirical generalizations in the context of a model that affords few novel predictions. In other words, it should be the sort of model Popper said would be of little interest to scientists. It should account for empirical generalizations that scientists consider central to the field, the findings that would prompt a researcher to say, "well yes, of course." And the model should predict nothing else.

One way to specify such a limited model is to compose it of the shared features of competing models within a domain—those are the features meant to account for the obvious phenomena, the outcomes that everyone agrees a model must capture. Murdock (1967) did so for memory models, calling the result the *modal model* of memory, invoking the mathematical mode to reflect the idea of "most frequently occurring." This is the familiar tripartite model of memory: a sensory register, short-term memory, and long-term memory. (It is often credited to Atkinson and Shiffrin, 1968, but that is in fact a particular instantiation of this architecture.) Gross (2015) recently offered a modal model of emotion (Figure 1).

Both of these modal models align with the cognitive epistemic assumptions. Again, I offer these models as examples. Modal models within behaviorist or constructivist frameworks could be equally appropriate. The criterion for success for a model is whether it will help prospective teachers make sense of empirical generalizations. Those, I suggest, should dominate teacher education.

Practitioners Need a Theory That Uses Folk Constructs

Psychological models typically evoke abstract ideas, and such ideas are often unintuitive to the beginning student: Skinner's free operant, for example, or the notion that knowledge might be distributed across a network and hence not represented in any one place. These ideas are challenging because they are new, and we understand new ideas in reference to ideas we already understand (e.g., Kendeou & Broek, 2007; Rittle-Johnson, Star, & Durkin, 2009; Williams & Lombrozo, 2013).

How, then, to help a teacher candidate understand the plethora of ideas, many of which will be novel, in an educational psychology course? The obvious solution would seem to be "simplify where possible and use analogies."

But if we bear in mind that the modal model is meant for a practitioner's purposes, not a researcher's, another solution becomes evident. Researchers need their models to make precise predictions so that they can be differentiated from other, similar models. It is the technicalities necessitated by precise predictions that make concepts difficult to understand for novices. For example, the inaccurate prediction of Baddeley and Hitch's (1974) model mentioned earlier was addressed in a more recent version of the model (Baddeley, 2012) by adding an episodic buffer that employs amodal representations. Amodality is a good example of an abstraction that is difficult to understand.

Such technicalities are unnecessary for practitioners. Modal models for prospective teachers should use folk psychological terms whenever doing so will not mislead. For example, the core properties of working memory can be conveyed with the intuitive observations that there is a mental "space" for thinking, that this space is limited, and that it can be occupied by things perceived in the environment and/or things from the long-term memory.

Researchers are leery of verbal descriptions of mental phenomena because they are imprecise and can lead to a false sense of understanding because they draw analogies to systems that are familiar. That is exactly what makes them useful for practitioners, provided that, of course, researchers

are confident that this informal theory is a close enough approximation to a model used by researchers.

In sum, teaching empirical generalizations to future teachers necessarily entails theoretical and epistemic claims. Many of the problems those claims bring to teacher education can be avoided using a modal model that employs folk psychological terms, within a single epistemology.

MOVING FORWARD

I have suggested substantial changes in how future teachers might learn educational psychology. Content should focus on empirical generalizations—regularities in children's thinking, emotion, and motivation. Students should encounter only a minimal number of simplified theories to integrate these empirical generalizations, and those simplified theories should be drawn from a single set of epistemic assumptions. The extent to which psychological principles can directly support classroom application must be made clear to future teachers. Finally, educational psychology should not be limited to a single-semester course; empirical generalizations should be revisited throughout teacher education, and some part of this education ought to include classroom observations regarding the application of empirical generalizations. If these changes were carried out, would teachers' practice improve? Would students benefit?

Empirical research shows that teachers *do* have a mental model of the learner (Beijaard & Verloop, 1996; Berliner, 1995) and it is influenced by their classwork (Brownlee, 2004; Sing Chai, Teo, & Beng Lee, 2009; Sosu & Gray, 2012; S. Walker, Brownlee, Whiteford, Exely, & Woods, 2012). It seems eminently reasonable that if changes to teacher education made the mental model more accurate and more internally consistent, students would benefit. Admittedly, there is only limited direct evidence that teachers' knowledge of educational psychology impacts students (Lunn, Walker, & Mascadri, 2015). Still, there is evidence that teacher knowledge of related constructs like general pedagogical knowledge (Shulman, 1986, which includes information about basic learning processes and classroom management and assessment) guides teachers' interpretations of events in their classrooms (Borko & Putnam, 1996; Fives & Buehl, 2012; Konig et al., 2014) and is associated with student ratings of instructional quality (Voss & Kunter, 2013). Thus, there is reason for optimism that a mental model of the learner focusing on the basic science of psychology would benefit teachers.

Reason for optimism, but still not hard evidence. More than 20 years ago, L. M. Anderson et al. (1995) called for more research to be directed to the utility of instruction in educational psychology, but the research base remains thin. That call is as relevant today as it was then, and should one or more programs rethink how they teach future teachers about educational psychology, that would provide a propitious opportunity to compare different curricula and practices of such instruction and to measure the outcomes.

REFERENCES

Agarwal, P. K., Bain, P. M., & Chamberlain, R. W. (2012). The value of applied research: Retrieval practice improves classroom learning and recommendations from a teacher, a principal, and a scientist. *Educational Psychology Review*, *24*, 437–448. https://doi.org/10.1007/s10648-012-9210-2

d'Ailly, H. (2003). Children's autonomy and perceived control in learning: A model of motivation and achievement in Taiwan. *Journal of Educational Psychology*, *95*, 84–96. https://doi.org/10.1037/0022-0663.95.1.84

American Federation of Teachers Teacher Preparation Task Force. (2012). *Raising the bar: Aligning and elevating teacher preparation and the teaching profession. A report of the American Federation of Teachers Teacher Preparation Task Force*. Washington, DC: American Federation of Teachers. Retrieved from http://www.aft.org/press-release/aft-report-teacher-preparation-recommends-bar-exam-and-demonstration

Anderman, L. H., & Leake, V. S. (2005). ABCs of motivation: An alternative for teaching prospective teachers about motivation. *The Clearing House*, *78*(5), 192–196.

Anderson, J. R., Reder, L., & Simon, H. (1997). Rejoinder: Situative versus cognitive perspectives: Form versus substance. *Educational Researcher*, *26*(1), 18–21.

Anderson, J. R., & Singley, M. K. (1989). *The transfer of cognitive skill*. Cambridge, MA: Harvard University Press.

Anderson, L. M., Blumenfeld, P., Pintrich, P. R., Clark, C. M., Marx, R. W., & Peterson, P. (1995). Educational psychology for teachers: Reforming our courses, rethinking our roles. *Educational Psychologist*, *30*(3), 143–157. https://doi.org/10.1207/s15326985ep3003_5

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. *Psychology of Learning and Motivation*, *2*, 89–95. https://doi.org/10.1016/S0079-7421(08)60422-3

Bacon, F. (2000). In *The new organon*. L. Jardine & M. Silverthorne (Eds.). Cambridge, England: Cambridge University Press. (Original work published 1620.)

Baddeley, A. (2012). Working memory: Theories, models, and controversies. *Annual Review of Psychology*, *63*, 1–29. https://doi.org/10.1146/annurev-psych-120710-100422

Baddeley, A. D., & Hitch, G. (1974). Working memory. *The Psychology of Learning and Motivation*, *8*, 47–89.

Baillargeon, R. (2004). Infants' reasoning about hidden objects: Evidence for event-general and event-specific expectations. *Developmental Science*, *7*, 391–414. https://doi.org/10.1111/j.1467-7687.2004.00357.x

Bartlett, F. C. (1932). *Remembering: A study in experimental and social psychology*. Cambridge, England: Cambridge University Press.

Beijaard, D., & Verloop, N. (1996). Assessing teachers' practical knowledge. *Studies in Educational Evaluation*, *22*(3), 275–286. https://doi.org/10.1016/0191-491X(96)00016-8

Bereiter, C. (2014). Principled practical knowledge: Not a bridge but a ladder. *Journal of the Learning Sciences*, *23*(1), 4–17. https://doi.org/10.1080/10508406.2013.812533

Berliner, D. C. (1992). Telling the stories of educational psychology. *Educational Psychologist*, *27*(2), 143–161. https://doi.org/10.1207/s15326985ep2702_2

Berliner, D. C. (1993). The science of psychology and the practice of schooling: The one hundred year journey of educational psychology from interest, to disdain, to respect for practice. In T. K. Pagan & G. R. VandenBos (Eds.), *Exploring applied psychology: Origins and critical analysis* (pp. 37–78). Washington, DC: American Psychological Association.

Berliner, D. C. (1995). The nature of expertise in teaching. In F. K. Oser, A. Dick, & J. L. Patry (Eds.), *Effective and responsible teaching: The new synthesis*. (pp. 227–248). San Francisco, CA: Jossey-Bass.

Berliner, D. C. (2001). Learning about and learning from expert teachers. *International Journal of Educational Research*, *35*, 463–482. https://doi.org/10.1016/s0883-0355(02)00004-6

Borko, H., & Putnam, R. T. (1996). Learning to teach. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 673–708). New York, NY: Macmillan.

Brownlee, J. (2004). An investigation of teacher education students' epistemological beliefs: Developing a relational model of teaching. *Research in Education*, *72*, 1–18.

Calfee, R. (1981). Cognitive psychology and educational practice. *Review of Research in Education*, *9*(1), 3–73. https://doi.org/10.3102/0091732x009001003

Cameron, J., Banko, K., & Pierce, W. (2001). Pervasive negative effects of rewards on intrinsic motivation: The myth continues. *Behavior Analyst*, *24*, 1–44.

Chincotta, D., Underwood, G., Ghani, K. A., Papadopoulou, E., & Wresinski, M. (1999). Memory span for arabic numerals and digit words: Evidence for a limited-capacity, visuospatial storage system. *Quarterly Journal of Experimental Psychology Section A*, *52*, 325–351. https://doi.org/10.1080/713755822

Cowan, N. (1999). An embedded-processes model of working memory. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 62–101). Cambridge, England: Cambridge University Press.

Curd, M., Cover, J. A., & Pincock, C. (2012). *Philosophy of science: The central issues* (2nd ed.). New York, NY: W.W. Norton.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, *19*, 450–466.

Deci, E. L., Ryan, R. M., & Koestner, R. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, *125*, 627–668.

Duhem, P. (1954). *The aim and structure of physical theory*. P. W. Wiener (Ed.). Princeton, NJ: Princeton University Press. (Original work published 1914.)

Eraut, M. (1994). *Developing professional knowledge and competence*. New York, NY: Routledge.

Ericsson, K., Charness, N., Feltovich, P., & Hoffman, R. (2006). *The Cambridge handbook of expertise and expert performance*. Cambridge, England: Cambridge University Press.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review*, *102*(2), 211–245. https://doi.org/10.1037/0033-295x.102.2.211

Fives, H., & Buehl, M. (2012). Spring cleaning for the "messy" construct of teachers' beliefs: What are they? Which have been examined? What can they tell us? In K. R. Harris, S. Graham, & T. Urdan (Eds.), *APA educational psychology handbook* (Vol. *2*, pp. 471–499). Washington, DC: American Psychological Association.

Gage, N. L. (1978). *The scientific basis of the art of teaching*. New York, NY: Teachers College Press.

Gelman, R. (1983). Recent trends in cognitive development. In C. J. Scheirer & A. M. Rogers (Eds.), *The G. Stanley Hall lecture series* (Vol. 3, pp. 145–177). Washington, DC: American Psychological Association. https://doi.org/10.1037/10088-005

Gick, M. L., & Holyoak, K. J. (1983). Schema induction and analogical transfer. *Cognitive Psychology*, *15*(1), 1–38. https://doi.org/10.1016/0010-0285(83)90002-6

Gilovich, T. D., & Griffin, D. W. (2010). Judgment and decision making. In S. T. Fiske, D. T. Gilbert, & G. Lindzey (Eds.), *Handbook of social psychology* (5th ed., pp. 542–588). Hoboken, NJ: John Wiley.

Greeno, J. G. (1989). A perspective on thinking. *American Psychologist*, *44*(2), 134–141. https://doi.org/10.1037/0003-066x.44.2.134

Greeno, J. G. (1997). Theories and practices of thinking and learning to think. *American Journal of Education*, *106*(1), 85–126.

Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry*, *26*, 1–26.

Hanson, N. R. (1958). *Patterns of discovery: An inquiry into the conceptual foundations of science*. Cambridge, England: Cambridge University Press.

Hilgard, E. R., & Bower, G. H. (1975). *Theories of learning* (4th ed.). Englewood Cliffs, NJ: Prentice-Hall.

Hobson, A. J. (2003). Student teachers' conceptions and evaluations of "theory" in initial teacher training (ITT). *Mentoring and Tutoring: Partnership in Learning*, *11*(3), 245–261. https://doi.org/10.1080/1361126032000138300

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin*, *114*(1), 3–28. https://doi.org/10.1037/0033-2909.114.1.3

Kazdin, A. E., & Bootzin, R. R. (1972). The token economy: An evaluative review. *Journal of Applied Behavior Analysis*, *5*, 343–372. https://doi.org/10.1901/jaba.1972.5-343

Kendeou, P., & van den Broek, P. (2007). The effects of prior knowledge and text structure on comprehension processes during reading of scientific texts. *Memory and Cognition*, *35*, 1567–1577.

Kiewra, K. A., & Gubbels, P. S. (1997). Are educational psychology courses educationally and psychologically sound? What textbooks and teachers say. *Educational Psychology Review*, *9*(2), 121–148. https://doi.org/10.1023/a:1024788428888

Konig, J., Blomeke, S., Klein, P., Suhl, U., Busse, A., & Kaiser, G. (2014). Is teachers' general pedagogical knowledge a premise for noticing and interpreting classroom situations? A video-based assessment approach. *Teaching and Teacher Education*, *38*, 76–88. https://doi.org/10.1016/j.tate.2013.11.004

Korthagen, F. A. J., & Kessels, J. P. A. M. (1999). Linking theory and practice: Changing the pedagogy of teacher education.

Educational Researcher, *28*(4), 4–17. https://doi.org/10.3102/0013189x028004004

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.

Lave, J., & Wenger, E. (1991). *Situated learning*. Cambridge, England: Cambridge University Press.

Long, G. M. (1980). Iconic memory: A review and critique of the study of short-term visual storage. *Psychological Bulletin*, *88*, 785–820. https://doi.org/10.1037/0033-2909.88.3.785

Lunn, J., Walker, S., & Mascadri, J. (2015). Personal epistemologies and teaching. In H. Fives & M. G. Gill (Eds.), *International handbook of research on teachers' beliefs* (pp. 319–335). New York, NY: Routledge.

Matlin, M. W. (2012). *Cognition* (8th ed.). New York, NY: Wiley.

McCulloch, W., & Pitts, W. (1943). A logical calculus of the ideas immanent in nervous activity. *The Bulletin of Mathematical Biophysics*, *7*, 115–133.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *63*(2), 81–97. https://doi.org/10.1037/h0043158

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior*, *16*, 519–533. https://doi.org/10.1016/s0022-5371(77)80016-9

Murdock, B. B., Jr. (1967). Recent developments in short-term memory. *British Journal of Psychology*, *58*, 421–433. https://doi.org/10.1111/j.2044-8295.1967.tb01099.x

von Neumann, J. (1958). *The computer and the brain*. New Haven, CT: Yale University Press.

Newell, A., Shaw, J. C., & Simon, H. A. (1958). Elements of a theory of human problem solving. *Psychological Review*, *65*(3), 151–166. https://doi.org/10.1037/h0048495

O'Donnell, A. M., & Levin, J. R. (2001). Educational psychology's healthy growing pains. *Educational Psychologist*, *36*(2), 73–82. https://doi.org/10.1207/s15326985ep3602_2

Pai, H.-H., Sears, D. A., & Maeda, Y. (2015). Effects of small-group learning on transfer: A meta-analysis. *Educational Psychology Review*, *27*(1), 79–102. https://doi.org/10.1007/s10648-014-9260-8

Patrick, H., Anderman, H. H., Bruening, P. S., & Duffin, L. C. (2011). The role of educational psychology in teacher education: Three challenges for educational psychologists. *Educational Psychologist*, *46*(2), 71–83. https://doi.org/10.1080/00461520.2011.538648

Peterson, L., & Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology*, *58*(3), 193–198. https://doi.org/10.1037/h0049234

Phillips, D. C. (1996). Philosophical perspectives. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 1005–1019). New York, NY: Macmillan.

Piaget, J. (1952). *The origins of intelligence in children*. New York, NY: International Universities Press.

Piaget, J. (1954). *The construction of reality in the child*. New York, NY: Basic Books.

Popper, K. R. (1963). *Conjectures and refutations: The growth of scientific knowledge*. New York, NY: Routledge.

Proctor, R. W., & Dutta, A. (1995). *Skill acquisition and human performance*. Thousand Oaks, CA: Sage.

Putnam, H. (1960). Minds and machines. In S. Hook (Ed.), *Dimensions of mind: A symposium* (pp. 138–164). New York, NY: Collier.

Quine, W. V. (1951). Main trends in recent philosophy: Two dogmas of empiricism. *The Philosophical Review*, *60*(1), 20–43. https://doi.org/10.2307/2181906

Reisberg, D. (2015). *Cognition* (6th ed.). New York, NY: W. W. Norton.

Rittle-Johnson, B., Star, J. R., & Durkin, K. (2009). The importance of prior knowledge when comparing examples: Influences on conceptual and procedural knowledge of equation solving. *Journal of Educational Psychology*, *101*, 836–852. https://doi.org/10.1037/a0016026

Sadler, T. D., Burgin, S., McKinney, L., & Ponjuan, L. (2010). Learning science through research apprenticeships: A critical review of the literature. *Journal of Research in Science Teaching*, *47*(3), 235–256. https://doi.org/10.1002/tea.20326

Sechenov, I. M. (1935). Reflexes of the brain. In A. A. Subkov (Ed. and Trans.), *I. M. Sechenov: Selected works*. Moscow, Russia: State Publishing House for Biological and Medical Literature. (Original work published 1863.)

Shuell, T. J. (1996). The role of educational psychology in the preparation of teachers. *Educational Psychologist*, *31*(1), 5–14. https://doi.org/10.1207/s15326985ep3101_1

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. https://doi.org/10.2307/1175860

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1–21. https://doi.org/10.1007/springerreference_17273

Sing Chai, C., Teo, T., & Beng Lee, C. (2009). The change in epistemological beliefs and beliefs about teaching and learning: A study among pre-service teachers. *Asia-Pacific Journal of Teacher Education*, *37*, 351–362. https://doi.org/10.1080/13598660903250381

Sosu, E. M., & Gray, D. S. (2012). Investigating change in epistemic beliefs: An evaluation of the impact of student teachers' beliefs on instructional preference and teaching competence. *International Journal of Educational Research*, *53*, 80–92. https://doi.org/10.1016/j.ijer.2012.02.002

Thorndike, E. L. (1910). The contribution of psychology to education. *Journal of Educational Psychology*, *1*(1), 5–12. https://doi.org/10.1037/h0070113

Tulving, E. (1962). Subjective organization in free recall of "unrelated" words. *Psychological Review*, *69*, 344–354. https://doi.org/10.1037/h0043150

Ucros, C. G. (1989). Mood state-dependent memory: A meta-analysis. *Cognition and Emotion*, *3*(2), 139–169. https://doi.org/10.1080/02699938908408077

Voss, T., & Kunter, M. (2013). Teachers' general pedagogical/psychological knowledge. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 207–227). New York, NY: Springer.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. M. Cole, V. John-Steiner, S. Scribner & E. Souberman (Ed. and Trans.). Cambridge, MA: Harvard University Press.

Walker, M. P. (2012). The role of sleep in neurocognitive function. In C. M. Morin & C. A. Espie (Eds.), *The Oxford handbook*

of sleep and sleep disorders (pp. 110–130). New York, NY: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780195376203.013.0007

Walker, S., Brownlee, J., Whiteford, C., Exely, B., & Woods, A. (2012). A longitudinal study of change in prospective teachers' personal epistemologies. *Australian Journal of Teacher Education*, *37*(5), 24–35. https://doi.org/10.14221/ajte.2012v37n5.1

Watson, J. B. (1913). Psychology as the behaviorist views it. *Psychological Review*, *20*(2), 158–177. https://doi.org/10.1037/h0074428

Williams, J. J., & Lombrozo, T. (2013). Explanation and prior knowledge interact to guide learning. *Cognitive Psychology*, *66*(1), 55–84. https://doi.org/10.1016/j.cogpsych.2012.09.002

Willingham, D. T. (2009) *Why don't students like school?* San Francisco, CA: Jossey-Bass.

Woodworth, R. S., & Thorndike, E. L. (1901). The influence of improvement in one mental function upon the efficiency of other functions. *Psychological Review*, *8*(3), 247–261. https://doi.org/10.1037/h0074898