The Psychology of Academic Achievement

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Abstract

Educational psychology has generated a prolific array of findings about
factors that influence and correlate with academic achievement. We re-
view select findings from this voluminous literature and identify two do-
mains of psychology: heuristics that describe generic relations between
instructional designs and learning, which we call the psychology of "the
way things are," and findings about metacognition and self-regulated
learning that demonstrate learners selectively apply and change their
use of those heuristics, which we call the psychology of "the way learn-
ers make things." Distinguishing these domains highlights a need to
marry two approaches to research methodology: the classical approach,
which we describe as snapshot, bookend, between-group experimen-
tation; and a microgenetic approach that traces proximal cause-effect
bonds over time to validate theoretical accounts of how learning gen-
erates achievements. We argue for fusing these methods to advance a
validated psychology of academic achievement.

Contents

INTRODUCTION

"Extensive" significantly understates the scope of research relevant to a psychology of academic achievement. Not having examined all relevant books, chapters, proceedings, and articles—a task we estimate might require three decades of full-time work—we nonetheless posit it is possible to develop a unified account of why, how, and under what conditions learners succeed or fail in school. That account could lead to powerful theories about improving educational practices. Advancing toward such a model is our aim here although, necessarily, much has been omitted from our review. Like all models, our model will have limitations.

The model we sketch acknowledges two categories of psychological phenomena. The first concerns a psychology of "the way things are." By this we mean psychological phenomena that, in principle, are universal among learners and across subject areas and are not likely under learners' control. One example is that cognition can simultaneously manage only a limited number of tasks or chunks of information. Another is that learners express biases that can be shaped by information in their environment. This is the framing effect. A third is that information studied and then immediately restudied will be recalled less completely and less accurately than if restudying is delayed.

The second category concerns a psychology of "the way learners make things." In this category we consider learners as agents. Agents choose among tasks and among psychological tools for working on tasks. An example is deciding whether to prepare for an exam by massed or spaced review. Another example is deciding whether and how long to try retrieving information when it can't be found but there is a feeling of knowing it. If learners have knowledge of several mnemonic techniques for recalling information, they can choose among those mnemonics. If a first choice fails but strengthens the feeling of knowing, learners can metacognitively monitor what they did to make an informed choice about the next mnemonic technique to try. They have the option to interpret success and failure as due to effort or ability. When these choices are made and acted on, new information is created and feeds forward. In this way, learners shape their learning environment.

Is it important to distinguish between psychologies of the way things are and the way learners make things? In his recent review of research on memory, Roediger (2008, p. 247) wrote: "The aim of this review has been to remind us of the quest for laws and the difficulty in achieving them. . . . The most fundamental principle of learning and memory, perhaps its only sort of general law, is that in making any generalization about memory one must add that 'it depends.'" We suggest Roediger's lament may derive from failing to incorporate our distinction. While one significant source of variance in the psychology of academic achievement is due to the way things are, a second

significant source of variance originates in the psychology of the way learners make things. We argue that a psychology of academic achievement must account for how each psychology separately and jointly affects achievement.

Our account of the psychology of academic achievement also borrows a view presented by Borsboom et al. (2003). In brief, they argue and we agree that both kinds of psychology have been hampered, even misled, by failing to address proximal psychological processes. We consider questions about psychological processes that are shaped and constrained by how things are, and about processes that provide tools with which learners make things. In our account, we portray academic achievement as the result of self-regulated learning and argue that improving research entails rethinking constructs and the paradigm that guides experimental research.

COGNITIVE FACTORS

Since the publication of Thorndike's (1903) classic book *Educational Psychology*, the field has generated thousands of studies. Most investigated how environmental factors can be designed and how conditions within learners can be arranged to promote learning facts, principles, skills, and schemas. Recently, a consortium of approximately 35 eminent researchers (see **http://psyc.memphis.edu/learning/index. shtml**) summarized from this voluminous library 25 empirically grounded heuristics for instructional designs (see **Table 1**).

Intending no slight to the range of work contributing to each heuristic, we choose cognitive load theory to epitomize the category of a psychology describing "the way things are."

The Example of Cognitive Load

The construct of cognitive load has proven a powerful explanatory device for spanning the oft-cited gap between a science of learning and the arts of teaching and instructional design. Sweller (1988) developed cognitive load theory from models of working memory (e.g.,

Baddeley & Hitch 1974) that emphasized the limited capacity of working memory as a fundamental resource bottleneck in cognition. Vis-à-vis instruction, cognitive load is the total processing required by a learning activity. It has three components. First, intrinsic load is due to the inherent difficulty of an instructional task. It is indexed by the number of active interacting schemas needed to perform the task. Intrinsic load cannot be directly reduced by manipulating instructional factors. However, as the learner forms schemas and gains proficiency, intrinsic load decreases. Second, germane load arises from the cognitive processing that forms those schemas and boosts proficiency. Third, extrinsic cognitive load is any unnecessary processing. This load can be eliminated by manipulating instructional factors.

The three forms of cognitive load are additive; their sum cannot exceed working memory's limited capacity (Paas et al. 2003a). Intrinsic processing receives priority access to working memory. Remaining capacity is shared between germane and extrinsic processing. When total load is less than available capacity, an instructional designer, teacher, or learner can deliberately increase germane load to increase learning efficiency. Changing instructional factors may reduce extrinsic load. If working memory capacity is fully loaded, this can free resources for germane processing and ultimately produce more efficient learning. Total cognitive load has been measured by real-time recordings of performance and psychophysiological indices. It is most commonly gauged by self-report ratings collected after the task (Paas et al. 2003b).

Cognitive load is now liberally cited as an explanatory construct in research ranging over chemistry problem solving (Ngu et al. 2009), moral reasoning (Murphy et al. 2009), driver performance (Reyes & Lee 2008), and even motherhood (Purhonen et al. 2008). When cited by researchers outside the learning sciences, the tripartite nature of cognitive load is typically disregarded.

Reducing extraneous cognitive load links to several heuristics in **Table 1**. It is the primary theoretical grounding for improving learning

Table 1 Twenty-five heuristics for promoting learning[a]

Contiguity effects	Ideas that need to be associated should be presented contiguously in space and time.
Perceptual-motor grounding	Concepts benefit from being grounded in perceptual motor experiences, particularly at early stages of learning.
Dual code and multimedia effects	Materials presented in verbal, visual, and multimedia form richer representations than a single medium.
Testing effect	Testing enhances learning, particularly when the tests are aligned with important content.
Spacing effect	Spaced schedules of studying and testing produce better long-term retention than a single study session or test.
Exam expectations	Students benefit more from repeated testing when they expect a final exam.
Generation effect	Learning is enhanced when learners produce answers compared to having them recognize answers.
Organization effects	Outlining, integrating, and synthesizing information produces better learning than rereading materials or other more passive strategies.
Coherence effect	Materials and multimedia should explicitly link related ideas and minimize distracting irrelevant material.
Stories and example cases	Stories and example cases tend to be remembered better than didactic facts and abstract principles.
Multiple examples	An understanding of an abstract concept improves with multiple and varied examples.
Feedback effects	Students benefit from feedback on their performance in a learning task, but the timing of the feedback depends on the task.
Negative suggestion effects	Learning wrong information can be reduced when feedback is immediate.
Desirable difficulties	Challenges make learning and retrieval effortful and thereby have positive effects on long-term retention.
Manageable cognitive load	The information presented to the learner should not overload working memory.
Segmentation principle	A complex lesson should be broken down into manageable subparts.
Explanation effects	Students benefit more from constructing deep coherent explanations (mental models) of the material than memorizing shallow isolated facts.
Deep questions	Students benefit more from asking and answering deep questions that elicit explanations (e.g., why, why not, how, what-if) than shallow questions (e.g., who, what, when, where).
Cognitive disequilibrium	Deep reasoning and learning is stimulated by problems that create cognitive disequilibrium, such as obstacles to goals, contradictions, conflict, and anomalies.
Cognitive flexibility	Cognitive flexibility improves with multiple viewpoints that link facts, skills, procedures, and deep conceptual principles.
Goldilocks principle	Assignments should not be too hard or too easy, but at the right level of difficulty for the student's level of skill or prior knowledge.
Imperfect metacognition	Students rarely have an accurate knowledge of their cognition, so their ability to calibrate their comprehension, learning, and memory should not be trusted.
Discovery learning	Most students have trouble discovering important principles on their own, without careful guidance, scaffolding, or materials with well-crafted affordances.
Self-regulated learning	Most students need training in how to self-regulate their learning and other cognitive processes.
Anchored learning	Learning is deeper and students are more motivated when the materials and skills are anchored in real-world problems that matter to the learner.

[a]Reproduced from **http://psyc.memphis.edu/learning/whatweknow/index.shtml**. An elaborated description of each principle plus citations identifying empirical support is available as *25 Learning Principles to Guide Pedagogy and the Design of Learning Environments*. Retrieved Jan. 2, 2009 from **http://psyc. memphis.edu/learning/whatweknow/25principles.doc**.

by eliminating unnecessary information (coherence), cueing learners' attention (signaling), colocating items to be mentally integrated (spatial contiguity), and synchronizing events to be mentally integrated (temporal contiguity) (Mayer 2005).

Laboratory tasks designed to elevate cognitive load are reported by learners to feel more difficult (Paas et al. 2003b). From this, we assume the state of working memory overload is consciously experienced. Thus, it is within the purview of metacognition. Students can avoid overload by segmenting complex tasks for sequential work or using external mnemonics such as notes or diagrams. The cost of adopting learning tactics is initially experienced as added difficulty. But this investment can pay off in the long run.

METACOGNITIVE FACTORS

Flavell (1971) is credited with motivating psychologists to research the "intelligent monitoring and knowledge of storage and retrieval operations—a kind of metamemory, perhaps" (p. 277). He succeeded wildly. Since then, the broader topic of metacognition—cognition focused on the nature of one's thoughts and one's mental actions, and exercising control over one's cognitions—has generated a body of work that merits its own *Handbook of Metacognition in Education* (Hacker et al. 2009).

Metacognition is basically a two-step event with critical features. First, learners monitor features of a situation. They may monitor their knowledge, whether a peer or resource can provide information, and possible consequences if they make a particular move in solving a problem. The metacognitive account of the situation is determined by what the learner perceives, which may differ from its actual qualities. Monitoring compares those perceived features to standards set by the learner. Often, these are linked to but not necessarily identical to standards indicated by a teacher, parent, or peer. Second, based on the profile of differences between the learner's perception of the situation and standards—which differences there are

and how large they are—the learner exercises control. The learner may choose to stay the prior course at a task's midpoint, adapt slightly or significantly, or exit the task to pursue something else. Together, these steps set the stage for self-regulated learning, a potentially ubiquitous activity (Winne 1995).

Learners are considered agents. This means they choose whether and how to engage in tasks. But learners are not omnipotent. Nor are they insulated from their cerebral and the external worlds. Agency is reciprocally governed: As learners change their local environment, the environment's web of causal factors modulates affordances available to them (Martin 2004). For example, having monitored a problem's statement and classified it as solvable, inherent spreading activation in memory may render information that the problem is difficult. This may arouse anxiety. Seeking information from a peer may return a reply that warrants a positive attribution to effort. Or, it may generate a negative view that success can't be achieved without help from others. Some information the environment provides (e.g., by spreading activation) is not controllable, whereas other information (e.g., the affect associated with a peer's assessment) can be at least partially the learner's choice.

Given this account, four metacognitive achievements can be identified: (*a*) alertness to occasions to monitor, (*b*) having and choosing useful standards for monitoring, (*c*) accuracy in interpreting the profile generated by monitoring, and (*d*) having and choosing useful tactics or strategies. After setting the stage to reach subject matter achievements by developing these metacognitive skills, two further steps are required: (*e*) being motivated to act and (*f*) modifying the environment or locating oneself in an environment that affords the chosen action (Winne & Nesbit 2009).

Alertness to occasions appropriate to metacognitive monitoring has not been much researched beyond studies of readers' capabilities to detect superficial (e.g., spelling) or meaningful errors in texts. In this limited domain, detecting errors is proportional to measures of

prior achievement and inversely proportional to load on working memory (Oakhill et al. 2005, Walczyk & Raska 1992). The former suggests that standards used in monitoring derive from prior knowledge, similar to what learners use to construct a situation model for new information (Kintsch 1988). The latter reflects that working memory's resources play a ubiquitous role in the economy of information processing.

Learners may struggle to assimilate useful standards and apply them in monitoring. Beyond simplistic misperceptions about what counts when assignments are graded, learners may focus on information at the wrong grain size. They may judge work at a global level when more-specific targets or items should be the standard (Dunlosky et al. 2005).

Research on learners' accuracy of metacognitive monitoring has blossomed under the rubric of judgments of learning. It is rooted in the concept of feeling of knowing (Hart 1965), a belief that information is in memory although it cannot be retrieved. There are four main findings. First, learners are poor at monitoring learning and have a bias toward overconfidence (Maki 1998). Second, engaging with information in meaningful ways, such as generating a summary of a large amount of information, can improve accuracy (see Thomas & McDaniel 2007). Third, accuracy improves by delaying monitoring so that learners experience recall (or lack of it) rather than just scan residual information in working memory (Koriat 1993, Nelson & Dunlosky 1991, Thiede et al. 2005). Fourth, after experiencing difficulty in recall, judgments shift from being overconfident to the opposite, dubbed the "underconfidence with practice effect" (Koriat et al. 2002).

Relatively much more research is available about tools learners have for exercising metacognitive control. These tools, commonly termed metacognitive skills or learning strategies, vary widely and are researched using two common experimental formats. The first trains learners to competence in a tactic and then compares pretraining performance to posttraining performance. The second compares trained learners to a group not trained in the tactic. Early studies investigated very specific learning tactics, such as whether young children could verbally mediate how they learned associations when rules governing associative pairs changed (Kendler et al. 1972). At the other end of this continuum, Dansereau and colleagues (see Dansereau 1985) trained undergraduates in a typology of strategies summarized by the acronym MURDER: set mood, understand requirements of a task, recall key features of task requirements, detail (elaborating) main ideas studied, expand information into organized forms (e.g., an outline), and review. In a semester-long course, students showed statistically detectable but modest benefits when using MURDER (Dansereau et al. 1979). Other research investigated various methods for engaging learners with information and providing opportunities to monitor (see Thomas & McDaniel 2007), including deciding when to stop initial study and when to restudy (see Rohrer & Pashler 2007), self-questioning (Davey & McBride 1986), and summarizing information in keyword (Thiede et al. 2003) or prose form (Thiede & Anderson 2003).

Haller et al. (1988) meta-analyzed 20 studies on the effects of metacognitive instruction on reading comprehension. The average effect size was 0.72. Hattie and colleagues (1996) meta-analyzed 51 newer studies in reading and other subject areas. The average effect sizes due to training in cognitive or metacognitive skills were 0.57 on performance, 0.16 on study skills expertise, and 0.48 on positive affect. Because comparison groups typically represent "business as usual" conditions, two corollaries are warranted: Learners don't naturally learn metacognitive skills to an optimum level, and schooling does not sufficiently remedy this disadvantage. Findings show training has immediate benefits, but they leave unanswered a critical question: Do positive effects of training persist and transfer?

Dignath et al. (2008) meta-analyzed research investigating whether primary school children could be trained to use theoretically more effective forms of self-regulated learning than they had developed themselves

and, if so, whether training benefited reading, writing, mathematics, science, other areas of academic performance, attributions, self-efficacy, and metacognitive strategies. Overall, various kinds of training in self-regulated learning produced a weighted effect size of 0.69. But there were two notable issues. First, results were quite variable. Second, the research was overly dependent on self-reports about psychological events such as metacognition and uses of learning tactics.

Metacognition is not "cold"—affect and motivationally "hot" variables interact, including attributions (Hacker et al. 2008), goal orientations (Vrugt & Oort 2008), epistemological beliefs (Pieschl et al. 2008), and self-efficacy. The picture here is complex and inconsistent, in part because learners' self-reports of motivation may not correspond to choices they make to study (Zhou 2008). A broader model of metacognition is needed.

MOTIVATIONAL FACTORS

Motivation is conceptualized as a factor that influences learning. It also is an outcome of learning sought for its own sake. As an influence, motivation divides into two broad categories: factors that direct or limit choices for engagement—choosing to study history for interest but mathematics out of necessity, and factors that affect intensity of engagement—trying hard versus barely trying. As an outcome, motivations concern satisfaction or some other inherent value.

The vast span of theories and empirical work on motivational factors and academic achievement was surveyed, in part, by Covington (2000) and Meece et al. (2006). Both reviews emphasized research on motivation arising from goal-orientation frameworks, so we briefly update that topic before turning to other issues.

Covington (2000) divided the field into two sectors grounded in Kelly's (1955) distinction between (*a*) motives as drives, "an internal state, need or condition that impels individuals toward action" (p. 173) and (*b*) motives as goals,

where "actions are given meaning, direction, and purpose by the goals that individuals seek out, and... the quality and intensity of behavior will change as these goals change" (p. 174). As Covington noted, this distinction can be arbitrary because the same behavior can be conceived as reflecting both forms.

We scan three main areas of contemporary research, acknowledging that others are omitted. Our choices reflect a judgment about the intensity of recent work in educational psychology and fit our view of learners as self-regulating.

Achievement Goals

Achievement goals describe what learners orient to when learning, particularly the instrumental role of what is learned. The main research question has been whether achievement goals existing before learning is engaged correlate with levels or types of learning. The reviews by Covington (2000) and Meece et al. (2006) provide ample evidence that different goals correlate variously with outcomes.

A more interesting issue for self-regulated learning is whether achievement goals shape or constrain activities learners choose as they strive for goals. According to this view, goals play the role of standards for metacognitively monitoring situations—a task or the classroom—to classify them in terms of options for behavior. For example, students holding mastery approach goals, defined as intentions to deeply and thoroughly comprehend a subject, may judge that a situation affords opportunity to substantially extend expertise. In contrast, learners with performance approach goals may classify that same situation (as an observer determines sameness) as offering excellent chances to prove competence to others. Because of their differing classifications, these learners may exercise metacognitive control to choose very different tactics for learning (e.g., Dweck & Master 2008, Kolic-Vehovec et al. 2008, Miki & Yamauchi 2005, Pintrich & De Groot 1990).

This line of research faces several challenges. First, learners are not unidimensional

in their goal orientations (Pintrich 2000), so bindings between goal orientations and learning events are correspondingly complicated. Second, self-reports have been almost the only basis for researchers to identify goal orientation(s) (cf. Zhou 2008). One-time self-reports about adopted goals have some inherent validity—learners' declarations are what they are. But goals may be unstable, and the task's context may differ from the survey's context (Dowson et al. 2006). Like goal orientations, self-reports are almost the only data gathered to reflect tactics that learners use in learning. These self-reports also are contextually sensitive (Hadwin et al. 2001) and may not be trustworthy accounts of tactics learners actually use during study (Jamieson-Noel & Winne 2003, Winne & Jamieson-Noel 2002).

Together, these challenges weaken prior accounts about how goal orientations lead to choices of learning tactics that directly raise achievement. In addition to developing performance-based measures, gaining experimental control over goal orientation is a promising strategy for advancing research in this area (Gano-Overway 2008).

Interest

Interest predicts choices that learners make about where and how intensely to focus attention; whether to engage in an activity; and the intensity of, concentration on, or persistence in that engagement. Interest also describes a psychological state of positive affect related to features a learner perceives about the environment. Following a revival of research on interest and learning in the early 1990s (Renninger et al. 1992), two main forms of interest have been differentiated. Individual interest captures the predictive quality of interest, as in "I'm interested in science." Situational interest arises either from an opportunistic interaction between a person and features of the transient environment or because a learner exercises volition to create a context that is interesting.

Krapp (2005) reviewed research supporting a model that interest arises because learners experience feedback as they work. His model echoes Dewey's (1913) notion that a fusion of productive cognition and positive affect abets interest. Specifically, when feedback about task engagement supports a view of oneself as competent, agentic, and accepted by others, the task and its method of engagement acquire a degree of interest. Future tasks can be monitored for similar qualities, and the learner accordingly regulates future perceptions as well as engagement.

Research on interest documents that when a situation is monitored to match a priori interest, learners choose that situation, persist, and report positive affect as expected. As a consequence of persistence, learners usually learn more (Ainley et al. 2002). However, interest can debilitate when it leads learners to regulate learning by allocating more or more-intense cognitive processing to less-relevant but interesting content (Lehman et al. 2007, Senko & Miles 2008).

Interest dynamically interacts in complex ways with other variables that mediate the effects of interest and interest itself. A tiny sample of the roll call of these variables follows. Prior interest (Randler & Bogner 2007), prior knowledge, and the structure of knowledge in the domain (Lawless & Kulikowich 2006) all increase achievement and correlate with higher interest. Mastery goals and values attributed to tasks regarding their future utility and enjoyment (Hulleman et al. 2008) predict higher interest but not necessarily higher achievement. Self-concept of ability (Denissen et al. 2007) positively correlates with interest and mediates achievement. Need for cognition (Dai & Wang 2007) does the same. To this list we add self-monitoring and regulation, which we theorize increase students' sense of task-specific agency and consequently interest (Goddard & Sendi 2008). Given the centrality of teachers' and parents' concerns about students' interests in school topics and tasks, this tangle of findings begs for order. Some order might be achieved by applying Occam's razor to coalesce an overabundance of currently differentiated variables.

Epistemic Beliefs

Epistemic beliefs describe views a learner holds about features that distinguish information from knowledge, how knowledge originates, and whether and how knowledge changes. Two studies sparked an explosion of research in this area. The first was Perry's (1970) longitudinal study of undergraduates' developing views of these topics. The second was Schommer's (1990) extension of Ryan's (1984) study, showing that epistemic beliefs moderated comprehension of text.

A general conclusion is that epistemic beliefs predict interactions: When information is complex and probabilistic and its application in tasks cannot be definitively prescribed—when a task is ill-structured—learners who hold less well developed and less flexible epistemic beliefs recall, learn, argue, and solve problems less well than do peers with better developed snd more flexible epistemic beliefs (e.g., Mason & Scirica 2006, Stathopoulou & Vosniadou 2007). But when tasks and information are not ill structured, holding sophisticated epistemological beliefs can interfere with recall and comprehension (Bräten et al. 2008). In short, match of aptitude to task matters.

Muis (2007) synthesized theory and research on epistemic beliefs and self-regulated learning. She offered four main conclusions. First, learners observe features of tasks that reflect epistemic qualities (Muis 2008). Second, they use these perceptions to set goals and frame plans for accomplishing work. Third, as work on a task proceeds, learners use epistemic standards to metacognitively monitor and regulate learning processes (Dahl et al. 2005). Last, engaging in successful self-regulated learning can alter epistemic beliefs, specifically, toward a more constructivist stance (Verschaffel et al. 1999).

CONTEXT FACTORS

Peer-Supported Learning

Peer-supported learning encompasses collaborative, cooperative, and small-group arrangements in dyads or groups of up to about six members. It is theorized to offer multiple social, motivational, behavioral, metacognitive, and academic benefits. O'Donnell (2006) observed that the varied models of peer-supported learning are founded on theories emphasizing sociomotivational or cognitive aspects of the collaborative process.

Sociomotivationally grounded approaches to cooperative learning highlight the role of positive interdependence among group members and individual accountability of each member. These approaches lead to forming groups that are heterogeneous in ability, gender, and ethnicity, and suggest teachers set goals that require students to work together. For example, Slavin (1996) developed types of cooperative learning in which the whole group is rewarded for each of its members' gains in performance, thus incentivizing mutual support for learning within the group. In what he called the social cohesion approach (e.g., Johnson & Johnson 1991), small groups work on developing social skills, concern for others, and giving productive feedback and encouragement. In this approach, group members take on predefined roles (e.g., note keeper), and the teacher assigns a single grade for the group's work to reduce intragroup competition and promote positive interdependence.

Moderate achievement benefits arise from types of peer-supported learning that include positive interdependence, particularly in the form of interdependent reward contingencies (Rohrbeck et al. 2003, Slavin 1996). Using structured roles, as advocated by social cohesion theorists, appears to have little or no effect on achievement (Rohrbeck et al. 2003) but may boost students' social competence and self-concept (Ginsburg-Block et al. 2006). Peer-supported learning interventions are particularly effective in boosting achievement, social competence, self-concept, and task behavior among urban, low-income, minority students (Ginsburg-Block et al. 2006, Rohrbeck et al. 2003). Cooperative tasks designed to enhance student autonomy, such as allowing students to select goals and monitor and evaluate performance, enhance social skills, self-concept, and

achievement. A plausible but unresearched hypothesis is that practicing metacognitive control at the group level may help internalize metacognitive control at the individual level.

Cognitive theories of peer-supported learning claim it strengthens individual students' cognitive and metacognitive operations more than solo learning. Peer-supported learning is thought to offer more opportunities for retrieving and activating schemas, elaborating new knowledge, self-monitoring, and exercising metacognitive control (O'Donnell 2006). For example, using a method called guided reciprocal peer questioning (King 2002), a teacher might present a list of generic question stems such as "How does...affect...?" and invite students to use the question stems to generate topic-relevant questions they can pose within their small group or dyad. Students can also learn to pose metacognitive questions, such as "How do you know that?" Having pairs of elementary students generate questions from cognitive question stems can enhance learning outcomes (King 1994, King et al. 1998), but the efficacy of metacognitive prompting by peers is less certain.

A student who helps another by generating an explanation often learns more from the exchange than does the student who receives the explanation (Webb & Palincsar 1996). In research investigating why only some students who need help benefit from explanations, Webb & Mastergeorge (2003) described several qualities of successful help-seekers. They persisted in requesting help until they obtained explanations they understood. They attempted to solve problems without assistance and asked for specific explanations rather than answers to problems. These students adopted difficult but productive standards for monitoring and controlling learning. Classroom observations by Webb et al. (2008) indicate that teachers in primary grades can substantially increase the quality and quantity of explanations peers generate in collaborative groups by encouraging them to request additional explanations that extend or clarify an initial explanation. From the perspective of SRL, teachers who provide such encouragements are leading students to set higher standards for metacognitive monitoring.

In Piagetian terms, equal-status peer interactions are more likely to trigger cognitive disequilibrium, thus engendering more engaged cooperation than do adult-child interactions (De Lisi 2002). After exposure to peers' differing beliefs, dialogue can develop a new understanding that restores equilibrium. In Piaget's theory, this process is hindered if collaborators have unequal status, as in adult-child interactions, because the higher-status participant is less likely to be challenged, and the lower-status participant tends to accept the other's beliefs with little cognitive engagement. In other words, this is a form of self-handicapping metacognitive monitoring and control. In contrast, Vygotsky (1978) held that children construct knowledge primarily by internalizing interactions with a more capable participant who adjusts guidance to match the less capable participant's growing ability. This calls for sophisticated monitoring of a peer's understanding and sensitive metacognitive control that is gradually released to the developing learner. Studies of learning gains by children who collaboratively solved problems without external feedback found that among children paired with a lower-ability, similar-ability, or higher-ability partner, only those paired with a higher-ability partner tended to benefit from collaboration (Fawcett & Garton 2005, Garton & Pratt 2001, Tudge 1992). Tudge (1992) found that the members of similar-ability dyads were at risk of regressing in performance as a result of collaboration. These results favor Vygotsky's over Piaget's account of how status among collaborators stimulates knowledge construction.

How can learners of nearly equal knowledge and ability benefit from collaboration? How can more-capable children adjust help given to meet a peer's needs when they may be unable to monitor even their own abilities? Answers may lie in cognitive strategy instruction in which (*a*) the teacher guides and models group interactions and (*b*) students are assigned to roles that require metacognitive monitoring (Palincsar & Herrenkohl 2002). This approach is best

reflected in research on reciprocal teaching to improve the reading comprehension of below-average readers. Here, the teacher's role gradually shifts from direct explanation and modeling to coaching group interactions. A review of quantitative studies found that reciprocal teaching is consistently more effective than are methods in which teachers lead students in reading and answering questions about text passages (Rosenshine & Meister 1994).

For social-cognitive theorists, collaboration is an academic context to which individuals bring personal efficacy and achievement goals. Surprisingly, there is a lack of social-cognitive research on peer-supported learning (Pintrich et al. 2003). This is not because social-cognitive theories have no implications for collaborative learning. As an example, students who have performance avoidance goals and low personal efficacy are less likely to seek help from teachers and are theoretically also less willing to seek help from peers (Webb & Mastergeorge 2003). These students monitor collaborations using standards that handicap learning or lack skills for interacting with peers in more productive ways. At a more fundamental level, Bandura (2000) argued human groups manifest a collective efficacy, the members' perceptions of the efficacy of the group. Because collective efficacy is interdependent with group performance and the personal efficacy of its members, it has potentially important but unexplored implications for peer-supported learning. These and other unexamined implications of sociocognitive theory are opportunities to elaborate peer-supported learning in terms of metacognitive monitoring and control.

Research has offered only weak accounts of the many opportunities for metacognitive monitoring and control in peer-supported learning, including soliciting and giving explanation, sharing appropriate schemas, and using appropriate standards for monitoring progress. Feldmann & Martinezpons (1995) found that individual self-regulation beliefs predicted collaborative verbal behavior and individual achievement. However, there is little evidence that self-regulatory ability improves

collaboration and, if so, which aspects of self-regulation affect qualities of collaboration that recursively promote academic achievement. In what is perhaps the most informative research in this area, low-achieving students were induced to approach a collaborative problem-solving activity with either learning or performance goals as standards for monitoring interactions (Gabriele 2007). Those with a learning goal demonstrated higher comprehension monitoring, more constructive collaborative engagement, and higher posttest performance. Without further research like this, the role played by metacognitive monitoring and control in peer-supported learning will remain obscure.

Classrooms and Class Size

The relationship between class size and student achievement has been widely studied. This issue is so alluring it has attracted researchers even from economics and sociology. Smith & Glass's (1980) meta-analysis established that reducing class size tends to raise students' achievement in a nonlinear relationship. Removing one student from a class of thirty tends to raise the class mean far less than removing one student from a class of two. In textbooks and thumbnail reviews, the nonlinearity of the effect is usually reduced to a simpler principle: gains in achievement are achieved when class size falls to 15 students or fewer.

Project STAR (Student Teacher Achievement Ratio), a large-scale experiment on class size, is lauded as one of the most significant educational investigations ever conducted (Mosteller 1995). The project randomly assigned approximately 12,000 Tennessee elementary school students and their teachers to small (13–17 students) and regular-sized (22–25 students) classes. The students entered the experiment in kindergarten, grade 1, grade 2, or grade 3. Although the intervention ended after grade 3, achievement data were collected until grade 9. In one analysis of the STAR data, Krueger (1999) concluded that students in their first year of small classes scored an average of

4 percentiles higher and increased that advantage in subsequent years of small classes by about 1 percentile per year. This analysis offers limited value to policy makers because the cost of reducing class sizes by one third is high, and other interventions are known to produce larger effects. Even more concerning is that the benefits of some educational interventions diminish rapidly after the intervention terminates.

Fortunately, a more-detailed picture has emerged from the STAR data. Krueger (1999) reported that low-socioeconomic-status (SES) students, African American students, and inner-city students all benefited from small class sizes more than did the general population. Evidence has also emerged that benefits obtained from small class sizes in grades K–3, including the extra gains for disadvantaged groups, persisted until at least grade 8 (Nye et al. 2004). There is an important complication: Small class sizes tend to increase variability in achievement and expand the gap between the highest- and lowest-achieving students (Konstantopoulos 2008). Still more challenging is that recent observational research reports no positive achievement effects from small class sizes in kindergarten (Milesi & Gamoran 2006).

Research relating class size and demographic variables to achievement fails to explain how learning is affected. Looking inside the black box of class size could shine light on this mystery. Blatchford and colleagues (2002, 2007) conducted a series of systematic observations in England of teaching and learning in small and regular-sized classrooms for students ages 11 and under. They found that children in small classes interacted more with their teachers, received more one-to-one instruction, and paid more attention to their teachers (Blatchford et al. 2002, 2007). Teachers and observers in small classes reported that more time was allocated to assessing individual student products and progress. Despite these impacts on teaching, Blatchford et al. (2007) concluded teachers may not take full advantage of reduced class size. They often persisted with more whole-class instruction than necessary and failed to adopt

cooperative learning strategies that become more feasible in smaller classes.

This is consistent with conclusions of the STAR project. On the whole, teachers assigned to smaller classes did not strategically modify their teaching (Finn & Achilles 1999). Indeed, taking a sociological perspective, Finn et al. (2003) proposed that improved learning outcomes in small classes are strongly mediated by students' sense of belonging and their academic and social engagement. Students' choices about how they learn and teachers' choices about how they teach are manifestations of metacognitive control. These choices are shaped by standards they each use to metacognitively monitor their circumstances and themselves. In short, standards matter. How do students and teachers acquire them, search for and select them, and use them in these situations?

If resources are allocated to decreasing class sizes in the early grades, how can administrators and teachers know when students are ready to learn in larger classrooms, where they have less teacher support? We speculate that students' abilities to independently monitor and regulate their learning are crucial to successful performance in larger classes. We recommend developing performance-based tools to assess when children have self-regulating skills for learning where there is less teacher attention.

Homework

In her article "Homework is a Complicated Thing," Corno (1996) described difficulties in forming widely applicable, evidence-based homework policies. Corno's title is still the best one-line summation of what is known about the psychology of homework. This is yet another case illustrating that hundreds of investigations using a variety of methods have only weakly informed teaching practices and policy, perhaps because these studies failed to consider learners as metacognitive agents.

Teachers assign readings, problem sets, reports, and projects as homework for a variety of instructional purposes, including practicing skills demonstrated in class, preparing

for class discussions, and creatively integrating and applying knowledge acquired from multiple sources (Epstein & Van Voorhis 2001). Homework also may be assigned with intentions to develop time-management and other self-regulatory skills, stimulate parental involvement, and foster parent-teacher communication.

Historically, homework has been controversial. Periodic calls to abolish it are grounded in claims that it is instructionally ineffective and pulls time away from family activities. Calls for abolishing homework interleave with calls for assigning more homework to increase children's preparation for a knowledge-based, competitive world. Homework can be misused when teachers assign too much or use it to punish (Corno 1996). In investigating links between stress and homework, Kouzma & Kennedy (2002) found Australian senior high school students reported a mean of 37 hours of homework per week. Time spent on homework correlated with self-reported mood disturbance. Advocates for educational equity have claimed that homework can increase the performance gap between high- and low-achieving students (McDermott et al. 1984).

The relationship between homework and academic achievement is most fully mapped in two landmark meta-analyses (Cooper 1989, Cooper et al. 2006). Cooper (1989) set out a detailed model of homework effects that includes (*a*) exogenous factors such as student ability and subject matter, and assignment characteristics such as amount and purpose; (*b*) classroom factors, such as the provision of materials; (*c*) home-community factors, such as activities competing for student time; and (*d*) classroom follow-up factors, such as feedback and uses of homework in class discussions. The strongest evidence for homework's efficacy comes from intervention studies, some using random assignment, in which students were or were not given homework. Cooper's meta-analyses statistically detected advantages due to homework in these studies, with weighted mean effect sizes for student test performance of $d = 0.60$ (Cooper et al. 2006) and $d = 0.21$ (Cooper

1989). In a review of studies correlating self-reported time spent on homework and achievement, Cooper et al. (2006) statistically detected a positive weighted average effect size of $r = 0.25$ for high school students but did not detect an effect for elementary students. They reported some evidence of a curvilinear relationship between amount of homework and performance. In Lam's study of grade 12 students cited by Cooper et al. (2006), the benefit from homework was strongest for students doing 7 to 12 hours of homework per week and weakest for students doing more than 20 or less than 6 hours per week.

Trautwein and colleagues (Trautwein 2007, Trautwein et al. 2009) argued that homework is a "classic example of the multi-level problem" whereby generally positive effects of homework reported in Cooper's meta-analyses mask considerable underlying complexity. Working with data from 1275 Swiss students in 70 eighth-grade classes, they distinguished three levels of analysis. At the class level, they found a positive relationship between the frequency of homework assigned by teachers and classes' achievement. At the between-individual level, achievement related positively to students' homework effort but negatively to homework time. At the intraindividual level, in which students were assessed longitudinally, the time-achievement effect flipped direction—homework time related positively to achievement.

Cooper and Trautwein and their colleagues call for better-designed and more-ambitious research on homework. As in so many areas of educational research, there is a need for large-scale experiments, longitudinal observations, hierarchical analyses, and improved methods for gathering qualitative, time-on-task, and fine-grained data that trace cognitive processes. Research also is needed on the effects of potentially moderating variables such as culture, grade level, subject area, cognitive ability, and the manifold factors identified in Cooper's model. Finally, there is a need to develop and investigate innovative homework activities and compare them with conventional forms of homework.

Alongside these macro-level relations, we theorize self-regulation is a key factor in determining the effects of homework activities. Here, there is a dearth of research. In one observational study, Zimmerman & Kitsantas (2005) found that homework experiences positively predicted secondary students' sense of personal responsibility and self-efficacy beliefs, including self-monitoring and organizing. Those beliefs predicted academic achievement. In research on the other side of the reciprocal relationship, training in homework self-monitoring was equally effective as parental monitoring in raising homework-completion rates above those of a no-intervention control group (Toney et al. 2003).

Socioeconomic Status

In educational research, SES is most commonly measured by a composite of parents' education, occupation, and income. Despite older, widespread beliefs about its overwhelming predictive power, SES is only a moderately strong predictor (relative to other known factors) of school achievement in the United States (White 1982). The most recent meta-analysis of U.S. studies found correlations between SES and achievement of 0.23 to 0.30 when measured at the student level (Sirin 2005). By comparison, this effect size is about the same as the meta-analytically derived correlation between parental involvement and achievement (Fan & Chen 2001) and considerably weaker than correlations of achievement with educational resources available in the home ($r = 0.51$) (Sirin 2005) and parental attitudes toward education ($r = 0.55$) (White 1982). Internationally, the effects of SES are pervasive and operate both within and between countries (Chiu & Xihua 2008).

Determining which factors mediate the relationship between SES and students' achievement is challenging because the relevant research is observational, and data range in levels from the student to whole countries. Using multilevel modeling of data from 25 countries, Park (2008) investigated the role of the home literacy environment (early home literacy activities, parental attitudes toward reading, and number of books at home) in mediating the relationship between parental education and reading performance. He found the home literacy environment strongly predicted reading achievement even after statistically controlling for parental education, but it only partially mediated the relationship between parental education and reading performance.

Another factor that may account for better reading performance by higher-SES children is orally transmitted vocabulary. A U.S. study (Farkas & Beron 2004) found a gap between the oral vocabulary of high- and low-SES children by three years of age, but this did not increase after children entered kindergarten. This suggests that school helps equalize prior differences between children from different socioeconomic backgrounds. A structural equation modeling study found that parent-led home learning experiences (e.g., reading, games, and trips to the zoo or park) mediated the relationship between SES and literacy (Foster et al. 2005). We have not found research investigating the relationship between SES and metacognitive monitoring and control and whether these skills mediate the effects of SES on achievement. Thus, a full explanation of how SES affects learning is not available.

In summary, low SES appears to create significant but not insurmountable barriers to achievement in elementary school and beyond. The effects of SES are likely mediated by factors such as educational resources available in the home, parental aspirations for their children's education, home literacy activities, and parental transmission of oral vocabulary. More high-quality research is needed to investigate the most effective types of interventions for low-SES children, especially whether programs that develop metacognitive and self-regulatory skills could reduce the disadvantages they face.

PERSISTENT DEBATES

Learning and Cognitive Styles

We have never met a teacher who held that teaching is maximally successful when all

learners are taught identically. The opposite view—that teaching should adapt to learners' individual differences—requires identifying one or more qualities of learners upon which to pivot features of instruction. One class of such qualities is styles.

Allport (1937) is credited with introducing the phrase "cognitive style" to describe people's preferred or customary approaches to perception and cognition. When situations involve learning, stylistic approaches are termed "learning styles" (Cassidy 2004).

In an early paper, Messick (1970) distinguished nine cognitive styles. More recently, Coffield et al. (2004) cataloged 71 different models grouped into 13 families. Kozhevnikov (2007) classified 10 major groupings. Sternberg et al. (2008) collapsed all these into two categories. Ability-based styles characterize the typical approach(es) a learner takes in achievement tasks, such as representing givens in a problem using symbolic expressions or diagrams. Personality-based styles describe a learner's preference(s) for using abilities. Typical and preferred approaches may or may not match.

A recent theoretical synthesis (Kozhevnikov 2007) described styles as "heuristics [that] can be identified at each level of information processing, from perceptual to metacognitive... [whose] main function is regulatory, controlling processes from automatic data encoding to conscious allocation of cognitive resources." Very few studies are researching this view. The vast majority of research in educational settings aligns with Messick's (1984) view that styles "are spontaneously applied without conscious consideration or choice across a wide variety of situations" (p. 61). Therefore, studies have mainly developed and contrasted self-report inventories or explored correlates of styles while attempting to show that matching styles to forms of instruction has benefits while mismatching does not. Learners often can reliably describe themselves as behaving stylistically. Their reports correlate moderately with various demographic variables, individual differences, and achievement (e.g., Watkins 2001, Zhang & Sternberg 2001). Contrary to expectations, matching instruction to style does not have reliable effects (Coffield et al. 2004).

There are challenges to using styles in psychological accounts of school performance. First, thorough and critical syntheses of the psychometric properties and validity of self-report style measures are scant. One of the few was Pittenger's (1993) review of the Myers-Briggs Type Indicator. He concluded, "...there is no convincing evidence to justify that knowledge of type is a reliable or valid predictor of important behavioral conditions" (p. 483). Second, studies investigating the match of self-reports to behaviors are also rare. Krätzig & Arbuthnott's (2006) study of visual, auditory, kinesthetic, and mixed learning styles found no correlation between self-reported preferences for styles and objective scores on cognitive tasks measuring what the style was about. The study of field dependency-independence by Miyake et al. (2001) led them to conclude that this style "should be construed more as a cognitive ability, rather than a cognitive style" (p. 456).

Discovery Learning

Discovery learning is most strongly associated with science and math education. It has roots in the Piagetian view that "each time one prematurely teaches a child something he could have discovered for himself, that child is kept from inventing it and consequently from understanding it completely" (Piaget 1970, p. 715). Bruner (1961) theorized that discovery learning fosters intrinsic motivation, leads to an understanding of and inclination toward the heuristics of inquiry, and allows for the active self-organization of new knowledge in a way that fits the specific prior knowledge of the learner. According to Hammer (1997, p. 489), discovery learning usually "refers to a form of curriculum in which students are exposed to particular questions and experiences in such a way that they 'discover' for themselves the intended concepts." In unguided and minimally guided discovery learning, the role of the teacher is constrained to providing a learning environment or problem space and perhaps posing

questions. In discovery learning, teacher-posed questions should lead the student toward Piagetian disequilibrium, which is conceived as cognitive conflict between prior knowledge and new information from the environment.

Proponents of discovery learning believe it produces highly durable and transferable knowledge, a claim consistent with some observational evidence. For example, children in grades one and two who spontaneously invented and used arithmetic strategies subsequently showed greater understanding of base 10 number concepts and better performance on transfer problems than did children who initially acquired the standard arithmetic algorithms from instruction (Carpenter et al. 1998).

In a widely cited review, Mayer (2004) criticized discovery methods that emphasize unguided exploration in learning environments and problem spaces. Describing a belief in the value of pure discovery learning as "like some zombie that keeps returning from its grave" (p. 17), he reviewed investigations in three domains—problem-solving rules, conservation strategies, and Logo programming strategies. Mayer (2004) observed how in each case, accumulated evidence favored methods in which learners received guidance. He questioned the supposed connection between discovery teaching methods and constructivist theories, arguing that cognitive activity, not behavioral activity, is the essential requirement for constructivist learning. He maintained that, as a consequence, "active-learning" interventions such as hands-on work with materials and group discussions are effective only when they promote cognitive engagement directed toward educational goals.

The debate often pits discovery learning against direct instruction. Direct instruction is a broad domain of explicit teaching practices that include stating learning goals, reviewing prerequisite knowledge, presenting new information in small steps, offering clear instructions and explanations, providing opportunity for frequent practice, guiding performance, and giving customized, explanatory feedback (Rosenshine 1987). Originating as an approach to teaching primary reading, direct instruction has been successful within a wide range of general- and special-education programs at the elementary level (Swanson & Hoskyn 1998).

Discovery learning has been seen as a tool for acquiring difficult, developmentally significant knowledge, such as the control of variables strategy (CVS) used in designing experiments. However, when Klahr & Nigam (2004) randomly assigned elementary students to learn CVS by discovery or direct instruction, many more succeeded in the direct-instruction condition. Moreover, on an authentic transfer task involving evaluating science fair posters, the many students in the direct instruction condition who showed success while learning performed as well as the few students in the discovery group who also showed success while learning. Dean & Kuhn (2007) randomly assigned students learning CVS to direct instruction, discovery learning, and a combination of the two. Direct instruction was presented only during an initial session, and the discovery learning treatment extended over 12 sessions. In this study, direct instruction produced an immediate advantage, which disappeared in a posttest and a transfer task given several weeks after the termination of the discovery learning sessions. Although both of these experiments implemented direct instruction as a single session in which CVS was presented and modeled by a teacher, the experiments failed to include teacher-guided practice with feedback, which is a powerful and essential component of direct instruction.

A review by Kirschner et al. (2006) explained the evidence against minimally guided instruction in terms of cognitive load theory. They cast discovery learning as a type of problem solving that requires a cognitively demanding search in a problem space. According to cognitive load theory, such a search is extrinsic load that requires time and cognitive resources that otherwise could be used for understanding and elaborative processing of solution schemas. To support this claim, they cited evidence that novices learn to solve problems more effectively by initially studying worked solutions

before starting to solve problems (Tuovinen & Sweller 1999).

Rittle-Johnson (2006) pointed out that discovery learning theorists tend to conflate the two separate cognitive processes of reasoning about solutions and inventing them. She did a 2×2 experiment in which elementary school children learning the concept of mathematical equivalence were assigned to either instruction or invention and either self-explanation or no self-explanation. The invention condition offered no advantages. Both instruction and self-explanation conditions produced advantages for procedural learning on a delayed posttest, and only self-explanation produced advantages for transfer. It may be that self-directed elaborative processing, in this case manifested as self-explanation, is the only way to obtain high-level transfer (Salomon & Perkins 1989). The search of the problem space entailed by unguided discovery may hinder high-level transfer by taxing cognitive resources.

Another explanation of evidence favoring guided instruction is that students lack metacognitive skills needed to learn from unguided exploration. They may be unable to manage time to explore all relevant possibilities, keep track of which conditions and cases they have already explored, accurately monitor what they know and need to know, and monitor what works over the course of learning.

There is a need for better theory and evidentiary support for principles of guided discovery. We recommend investigating multiple ways of guiding discovery so that, ideally, every child is led to the brink of invention and extensive search of the problem space is avoided. Metacognitive guidance could include suggestions to generate a hypothesis, to make a detailed action plan, and to monitor the gap between the research question and the observations. These cognitive and metacognitive activities improve learning outcomes (Veenman et al. 1994).

The timing of metacognitive guidance may be critical. Hulshof & de Jong (2006) provided "just-in-time" instructional tips in a computer-based environment for conducting simulated optics experiments. A new tip became accessible every three minutes and could be consulted at any time thereafter. Although consulting the tips was optional, and tips contained no information that was directly assessed by the posttest, students randomly assigned to a condition that provided the tips outperformed peers in a control condition on the posttest. A potential drawback to this type of optional support is that students may misjudge their need for guidance and fail to access a needed tip or make excessive use of tips to avoid genuine cognitive engagement with the problem (Aleven et al. 2003). Theories about guided learning that may emerge from such research should strive to account for the motivational, cognitive, and metacognitive factors reviewed in this article.

METHODOLOGICAL ISSUES IN MODELING A PSYCHOLOGY OF ACADEMIC ACHIEVEMENT

Paradigmatic Issues

The psychology of school achievement has been studied mainly within a paradigm that we suggest faces difficult challenges. Intending no disrespect, we call this the "snapshot, bookend, between-groups paradigm"—SBBG for short. Recall Roediger's (2008) conclusion that the "only sort of general law, is that in making any generalization about memory one must add that 'it depends'" (p. 247). We posit that his claim generalizes to most if not all findings in a psychology about the way things are because of rules for doing research according to the SBBG paradigm.

SBBG is snapshot because data that reflect the effect of a causal variable almost always are collected just once, after an intervention is over. We acknowledge some studies are longitudinal but maintain that snapshot studies overwhelmingly form the basis of today's psychology of academic achievement.

Beyond the shortcoming of insufficiently tracing events between the bookends of a learning session, there is another reason that educational psychology's snapshot-oriented

research paradigm may model academic achievement incompletely. Students in classrooms and people in training learn new information and shift motivation and affect across time. A snapshot study captures just one posttest or pre-to-post segment within a longer trajectory of psychological events. The field has insufficiently attended to how segments concatenate. This is a necessary concern in modeling a trajectory of learning because the next segment may not match a researcher's predicted concatenation. But this issue is not one to validate analytically and a priori. Data are required to characterize how, at any point in the trajectory of a learning activity, a learner metacognitively monitors and exercises the metacognitive control that forms a trajectory of learning.

SBBG is a bookend paradigm because researchers rarely gather data representing proximally cognitive or motivational events between the time when learners are randomly assigned to an intervention and the time when potential effects are measured after the intervention is over. Ideally, random assignment reduces the necessity to gather data before an intervention. (But see Winne 2006 for an argument about challenges to random assignment as a panacea for erasing extraneous variance.) Otherwise, premeasures are secured to reduce "error" variance by blocking or statistically residualizing the outcome variable. (But see Winne 1983 for challenges to interpretation that arise in this case.) Random assignment and premeasures cannot identify cognitive processes that create changes in achievement. Randomness cannot help researchers interpret a systematic effect. Change in a learner's achievement can be conditioned by an aptitude that remains constant for that learner during the intervention, but that change cannot be caused unless this aptitude varies during the intervention.

An alternative that could illuminate achievement-changing processes inside an intervention is to gather data to proximally trace those processes (Borsboom et al. 2003, Winne 1982). Regrettably, data of this kind are rarely gathered because it is impractical. (But see Winne 2006 for ideas about how

impracticalities might be overcome using software technologies.) Thus, in bookend experiments, psychological processes that unfold as learners experience the intervention must be inferred rather than validated using fine-grained data gathered over time between the experiment's bookends (Winne & Nesbit 2009). Traces of processing allow opening the book between a traditional experiment's bookends and viewing each "page" situated in relation to prior events and following events. This allows merging psychologies of "the way things are" with "the way learners make things." Modeling should honor the dual role of events observed at points within the intervention, first as the outcome of prior psychological process and second as a process that generates the next state. Empirically investigating a learning trajectory, therefore, entails gathering data that can more fully contribute to accounting for change over time. This stands in contrast to data that reflect only the cumulative products of multiple processes that unfold over time with an intervention.

SBBG is a between-groups paradigm because it forces interpretations about whether an intervention changes learners' achievement to be grounded in differences (variance) between the central tendencies of a treatment group versus a comparison group. Data are lacking that trace how learners make things. Therefore, variance within each group due, in part, to individuals' self-regulating learning—metacognitive monitoring and control applied "on the fly"—has to be treated as "residual" or "error." In fact, the epitome of an experiment in the between-groups tradition would zero out individual differences in the ways learners make things.

If learners are agents, this approach leaves out key parts of the story about how achievement changes. The between-groups experimental approach relieves this tension by explaining effects in terms of a psychological process that does not vary across individuals despite researchers' belief in variance in the way learners make things. Thus, without opening the book of each group member's experience,

"between-subjects models do not imply, test, or support causal accounts that are valid at the individual level" (Borsboom et al. 2003, p. 214). The result is that a psychology about the way things are becomes an "it depends" science because between-groups experiments must neglect causal effects that arise from individual differences in the way learners make things.

A Revised Paradigm

We suggest that a more productive psychology of academic achievement should probe and map how learners construct and use information within boundaries set by the way things are. This entails three major paradigmatic changes. First, gather data that trace variance in learners' psychological states over time during an intervention. Supplement snapshot data. Second, conceptualize trajectories of learning as a succession of outcomes reciprocally determined by learners who choose information and modes of processing it to construct successive informational products. Read between bookends. Third, in the many situations where random assignment is not feasible and even where it is, define groups of learners a posteriori in terms of trace data that prove learners to be approximately homogenous in their information processing. Fix causes at the individual level, then explore for mediating and moderating variables post hoc. A paradigm that includes tracing agents' self-regulated processes provides raw materials that can support grounded accounts of what happens in the psychology of academic achievement at the same time it accommodates variations in instructional designs.

SHAPES FOR FUTURE RESEARCH

We judge that the field of educational psychology is in the midst of striving to integrate two streams. One stream investigates whether achievement improves by manipulating instructional conditions (e.g., class size, discovery learning) or accommodating trait-like individual differences (e.g., epistemic beliefs) or social conditions (e.g., SES). In these studies, what

individual learners do inside the span of a learning session and how each learner adjusts goals, tactics, and perceptions have been of interest. But these generating variables have rarely been directly operationalized and, when acknowledged, they are mostly treated as error variance terms in analyses of data. The second stream of studies seeks to operationalize reciprocally determined relations among a learner's metacognition, broadly conceptualized, and outcomes. In these studies, bookend variables set a stage of movable props: standards for metacognitively monitoring and choices exercised in metacognitive control. Learners choose the information-processing tools they use within bounds of a psychology of the way things are.

We take as prima facie that changes in academic achievement have origins in psychological phenomena. Snapshot, bookend between-groups studies in educational psychology have not traced those phenomena, as Winne (1983) and Borsboom et al. (2003) argued. Educational psychology should turn its attention to methods that penetrate correlations among distal variables. The goal should be to develop maps of proximal psychological processes that reflect causes of learning. In doing so, we hypothesize research must concern itself with learners' metacognitive monitoring and control. These processes set into motion forms of self-regulated learning that have been demonstrated to influence achievement. Studies should be not only more intensely focused on proximal indicators of psychological processes; researchers also need to gather data inside the bookends of learning sessions to track reciprocally determined relations that shape learning trajectories. In short, we recommend that snapshot, bookend between-groups research be complemented with a microgenetic method (Siegler & Crowley 1991). This suggests several requirements. One is operationally defining traces to describe which psychological processes in the realm of "the way things are" are applied during learning. Another is determining which standards learners apply in their metacognitive monitoring that leads to metacognitive control. These data model the way learners make things.

By a mix of natural exploration and instruction, learners develop their own heuristics, reflective of a naïve psychology of the way things are, about how cognitive and external factors can be arranged to acquire and successfully use academic knowledge. As agents, they operationalize those heuristics by metacognitively monitoring and controlling mental states and by manipulating external factors. By tracking their academic achievements and side effects over time, they become informed about how to regulate engagement in learning to improve the results of subsequent engagements. In short, over time, self-regulating learners experiment with learning to improve how they learn alongside what they learn (Winne 1995).

Findings from the psychology of the way things are will become better understood as we advance the psychology of how learners make things. This will involve learning more about standards that learners use to metacognitively monitor, the nature of monitoring per se, how learners characterize a profile of features generated by monitoring, and how potential actions are searched for and matched to a profile generated by monitoring that sets a stage for metacognitive control. Metaphorically, because learners are in the driver's seat, educational psychology needs a model of how learners drive to understand more fully how they reach destinations of academic achievement. By incorporating metacognition and its larger-scale form, self-regulated learning, into data and analyses of data, rather than randomizing out these factors, we submit a psychology of academic achievement can advance theoretically and offer more powerful principles for practice.

Our hypothesis is that gluing together the two psychologies of the way things are and the way learners make things will reduce the degree of Roediger's "it depends" hedge on laws of memory (and learning). Two inherent sources of variance need examining: What do learners already know and access over the fine-grained course of a learning session? How do learners self-regulate learning across sessions to adapt in service of achieving their goals? Richer interpretations will need to be grounded on fine-grained trace data that fill in gaps about processes in learning, specifically: Which heuristics for learning do learners consider, choose, apply, and adapt? How do those processes by which learners make things and self-regulate unfold under constraints of how things are?

DISCLOSURE STATEMENT

The authors are not aware of any biases that might be perceived as affecting the objectivity of this review.

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