Developing Learners' Cognitive Strategies and the Motivation to Use Them: Rethinking Education Policy

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Abstract

Strategies – and the motivation to use them – are critical to helping learners solve complex problems and complete complex tasks. These strategies and motivation are specific to certain domains – such as science – and even specific to certain tasks. Policies to improve learners' strategies and motivations should consider the learners themselves, the teacher, and the learning environment. With regard to learners, teachers should explicitly foster an array of learner strategies and teach them when and how to use them; teachers should expect development across learners to vary depending on other cognitive aspects, such as knowledge, as well as other motivational aspects, such as their interest. Policies should enable and encourage teachers to individualize explicit strategy instruction for each student with teachers developing their own strategy instruction by reflecting on that instruction using action research (i.e., research that is done by teachers in their own areas of practice).

Developing Learners' Cognitive Strategies and the Motivation to Use Them: Rethinking Education Policy

Effective 21st Century problem solvers need not only the knowledge to solve problems, but they need to be able to use this knowledge adaptively and flexibly. This need is due to the increase in ill-structured (Chin & Chia, 2006; Simon, 1973) problems that individuals encounter both in their educational and career endeavors – career endeavors that may change multiple times over their lifetime. Ill-structured problems have multiple answers and often times require multiple ways to arrive at those answers. For instance, a computer programmer may need to think like a hacker and anticipate how a potential hacker plans to gain access to secure data and code software to protect this sensitive data. In order to accomplish this, they need an array of both cognitive and motivational strategies to do so. In this particular example – and more generally – the strategies employed to solve problems are often specific to that problem or domain (Alexander, Dinsmore, Parkinson, & Winters, 2011) – computer science in the case of this example. Thus, learners need an array of strategies, and the ability to employ these strategies appropriately across and within academic domains and tasks.

Cognitive strategies are thought processes that are "procedural, purposeful, effortful, willful, essential, and facilitative" (Alexander, Graham, & Harris, 1998, p. 130) to solve or make progress toward solving a particular problem or completing a particular task. For instance, when reading a text, a learner may decide to use some of their prior knowledge to elaborate on a particular idea in the text to comprehend it better. The reader intentionally employs this elaboration strategy, a procedure that takes cognitive effort, and facilitates understanding of the text.

Critically, the individual's motivations and beliefs propel or impede these cognitive strategies. Motivation and beliefs are the psychological phenomena that both initiate and sustain cognitive strategies, impacting their quality– either positively or negatively (Fryer, Ginns, & Walker, 2014; Hidi, Renninger, & Krapp, 2004; Simons, Dewitte, & Lens, 2004; Maarten Vansteenkiste et al., 2010). Motivation for strategy use, thereby, affects the quality of the task or problem-solving outcome. For instance, in many situations, both within formal education and more broadly across life-long learning, individuals will have a number of strategies they might employ to learn something new. Substantial research has demonstrated that when individuals are confident they can successfully engage with the task and when they see that the task is relevant (personally, to family, to society) they are more likely to employ a strategy that will yield deeper, more sustainable outcomes. These motivational strategies are necessary for an individual to employ their cognitive strategies. Without the necessary motivation, these effortful processes will likely remain underemployed. Even if initiated, they are unlikely to be sustained and less likely to result in meaningful learning outcomes.

These cognitive strategies and the motivations and beliefs that propel them do not develop on their own; many cognitive strategies need to be taught (e.g., Sawyer, Graham, & Harris, 1992) and the motivations-beliefs need to be nurtured (Hidi & Renninger, 2006), even directed (Vansteenkiste, Soenens, Verstuyf, & Lens, 2009). Thus, educational policies must provide the context in which learners – and their teachers – are afforded the necessary time and resources to develop the cognitive strategies and motivations and beliefs necessary to succeed in today's world.

Part I of this article lays out the science behind the development of cognitive strategies and the motivations and beliefs that sustain them, along with interventions that support them. Part II provides multiple policies that will contribute to suitable environments for learners to build cognitive and motivational strategies, in order to attain foundational knowledge, participate in academic domains, join the 21st century workforce and continue to learn across their lifespan. Finally, we recommend how researchers can build and revise theoretical models to further study the implementations of these policy alternatives.

Scientific Evidence about the Development of Learners' Cognitive Strategies and the Motivation to Use Those Strategies

The development of cognitive strategies. The development of cognitive strategies – thought processes aimed at solving a problem – can be characterized across multiple aspects of strategy use over time. First, one has to consider *which* strategies are used over time, and second, to consider *how* they are employed over time.

Selection of strategies changes over time. Individuals change the strategies they employ to solve problems in a given area. Two theoretical frameworks – Overlapping Waves Theory and the Model of Domain Learning – and their related empirical support can show why these shifts in strategy selection occur.

Overlapping Waves Theory (OWT; Siegler, 1996) has been utilized predominately in the domain of mathematics, but is applicable to other domains. Individuals use a variety of strategies to solve problems, these strategies are often employed in diverse ways, and the use of these strategies changes as a result of the learner's experience (Siegler, 2000). We can consider a small child adding single digits as a simple example. At first, the child might rely on dachtylomy – using the fingers on their hands to represent both addends and then counting all their fingers to find the sum. Gradually, as the child experiences these single digit addition problems over and over again, they may also utilize a new strategy, recalling the sum from memory. However, this new strategy might not instantaneously replace the old strategy. Rather, for a period, the dachtylomy and recall strategies may overlap. The child might then rely primarily on the recall strategy, but employ dachtylomy to check their answer or when they are unable to recall the correct answer. As their experience grows, the child might jettison the dachtylomy strategy altogether. This change – and overlap – in strategy use has been recorded across multiple areas of mathematics. OWT, and its associated empirical evidence, strongly suggests that even short-term strategy use is not linear, nor do strategies occur in isolation. Rather, the use of strategies is often highly orchestrated, depending on the particular task, the attributes of the learner (e.g., how well they can use these strategies), and the nature of the learning environment in which they are completing the task.

The Model of Domain Learning (MDL; Alexander, 2004) also addressed how these strategies might shift within different academic domains (e.g., mathematics, science, history). The MDL takes a broader view of learner development, tracking shifts in strategy use throughout the development of expertise in a particular academic domain. The MDL examines expertise as the development of domain-specific (and task-specific) knowledge, strategies, and interest that allow an individual to solve problems and complete tasks that are typical of experts in that domain. Thus, knowledge, strategies, and interest developed in one domain will not necessarily transfer to a different domain –an expert in particle physics will not necessarily be able to employ their expertise in the domain of theoretical mathematics. Likewise, strategies learned by a 15-year old in their geometry class cannot be brought to bear well in their history class.

The MDL, based on prior empirical evidence, predicts that as learners develop expertise, they will shift their use of strategies from more surface-level strategies to deeper-level strategies. Surface-level strategies are employed to better understand a problem, whereas deep-level strategies are employed to transform a problem based on additional information, such as one's prior knowledge (Dinsmore & Alexander, 2016). While surface-level strategies are sufficient for well-structured problems (those with one solution and one path to achieve that solution) and may be used more frequently by novices, deep-level strategies are required to solve ill-structured problems (those with multiple solutions and multiple paths to achieve those solutions) as they become experts. This shift from well-structured to ill-structured problems is typical as learners gain expertise (Alexander, 2004). These shifts in strategies have been empirically supported across a wide variety of academic domains including reading, writing, the physical and life sciences, the social sciences, the humanities, the arts, and the physical/kinesthetic domains (Dinsmore, Hattan, & List, 2018).

Aspects of strategy use that develop. In addition to the selection of strategies changing over time, shifts also occur in how the same (or different) strategies might be employed by a learner across time. Recently, a systematic review (Dinsmore, 2017) identified three aspects of strategy use that influence learning outcomes, such as task achievement or problem solving. These aspects are quantity, quality, and conditional use of strategies. Quantity refers to the *frequency* of use of a particular strategy during a task or problem. For example, while reading a text, someone might use a visualizing strategy (i.e., picturing something from the text in one's mind; Pressley & Afflerbach, 1995)—not at all or multiple times. Quality refers to *how well* one employs a given strategy. For example, one might use primary sources to argue an historical point of view (Van Sledright, 2008). If these primary sources were well selected, used well, and support the argument, that strategy would be of higher quality. If those primary sources were not well selected, not used well, or did not support the argument, the strategy would be of lower quality. Finally, conditional use refers to *when* a strategy is more effectively employed. For example, in science, determining when to use a trial and error method in experimentation versus knowing when to use a prior hypothesis to guide a particular experimental manipulation is possible only when the learner can determine which would be more beneficial under which circumstances.

This more nuanced view of strategy development contradicts previous assumptions that by simply employing more strategies better performance would result (e.g., Block, 2009). However, merely using more strategies does not always result in better outcomes

(Dinsmore, 2018). Specifically, when it was measured, the quality of strategy use tended to predict performance outcomes better than simply measuring the frequency of strategy use.

How these developments in cognitive strategy use help learners solve problems. The scientific evidence presented here supports the view that what strategies learners employ—and when—determines learning outcomes. This use of strategies in multiple domains, particularly as learners transition from well-structured problems to ill-structured problems, are critical to adaptive and flexible problem solving. Prescribing learners to use certain strategies at certain times is likely to lead to inflexible use of these strategies. And worse, failure to explicitly teach these strategies at all may likely lead to routinized approaches that fail to prepare learners to competently solve difficult problems (Sawyer et al, 1992).

The development of motivations and beliefs critical to cognitive strategy initiation, persistence and meaningful learning outcomes.

Essential motivation and beliefs theories for cognitive strategy pursuit. For initiation, persistence, and meaningful fulfillment of cognitive strategies, learners need two crucial psychological sources of support. The first is a belief in their ability to be successful in the strategy, and the second is that the outcomes of the strategy are relevant, preferably valuable to the individual. Two theories address these critical sources of support, and a third provides a path for the longer-term development of motivation-beliefs across and beyond formal education.

Perceived control theory (Skinner, 1995) builds on well-established psychological research (e.g., Rotter, 1966) demonstrating that the more an individual feels in control of their surroundings (i.e., understands the expectations and relationships that make-up the environment, while feeling confident of their abilities to function within it), the more likely they are to be motivated to engage with it. Self-efficacy is a perceived control construct (Skinner, 1996) and a component of social-cognitive theory (Bandura, 1986, 1993, 1997).

Self-efficacy beliefs are a powerful means of understanding both how perceived control directly affects learning and provides direction for how instruction and the broader learning environment might support it. Self-efficacy is defined as individual's belief in their ability to successfully complete a task or series of tasks (Bandura, 1993).

Value for both the process and outcomes of cognitive strategies determines why learners chose a cognitive strategy— and through that strategy, the quality of their learning outcomes. Several theories seek to frame value, but Self-Determination Theory (SDT; Deci & Ryan, 1985; Ryan & Deci, 2017) presents both the clearest organization and useful instructional implications. SDT organizes value across a regulation continuum, from a lack of regulation ("I don't know why I am doing this"), to external regulation ("I am doing this because I was told to"), and finally, to internal regulation ("I am doing this because it is relevant to me"). SDT stipulates that individuals with increasing personal reasons for employing cognitive strategies are more likely to employ them and more likely to do so in an adaptive manner (Vansteenkiste, Niemiec, & Soenens, 2010).

Interest, as a psychological state and developmental process (for a well-established summary of the research in this area see Hidi & Renninger, 2006), is supported by each of these motivations-beliefs. Furthermore, interest integrates them into a collative, (potentially) growing reason for employing cognitive strategies to engage with and understand the world. Interest describes a person-object relationship (it is domain, even topic specific) and is best defined as a desire to reengage with said object. As a model for understanding learners' motivation to learn, its usefulness arises from the fact that all teachers, parents and students already have an implicit understanding of what interest is and want more of it. Its usefulness can also be attributed to its clear, context embedded developmental nature. Interest, as it is commonly organized within the four-phase model of interest development (Hidi & Renninger, 2006; Renninger & Hidi, 2011, 2015), is described as potentially moving from situational interest (relying on emotional responses such as surprise, enjoyment, fear, even disgust), to maintained situational interest (i.e., largely relying on the environment, but also sustained by growing knowledge and value for the object), to emerging individual interest (while still needing support from the environment, it draws more evenly on confidence in one's understanding and value for the topic together yielding a burgeoning desire learn more), and finally, personal interest (as sustainable a source of motivation a humans ever achieve).

These motivations and beliefs are each, and together combined, a fundamental support structure for cognitive strategies. Cognitive strategies by their very nature are applied to challenging tasks and need to be applied across extended periods of time. In addition to supporting the initiation of and persistence in cognitive strategies, motivation has implicit (e.g., OWT) and explicit roles in strategy development (e.g., MDL) and choice of strategy deployment. Both OWT and MDL organize students' cognitive strategies across a developmental trajectory. Learners take these developmental steps only with constant support of their growing ability and ability beliefs. Learners therefore have a growing repertoire of strategies to draw upon, and their choices rely as much on their value for tasks (and their outcomes) as it does their belief about their ability to be successful in them. All else equal, learners pursuing personally relevant goals are both more likely to find tasks interesting and to employ deep processing strategies (Fryer, 2015; Simons et al., 2004).

Furthermore, cognitive strategies, regardless of their appropriateness and students' skills in employing them, will not always be successful. How learners react to failure chiefly depends on their perceived control over the situation and environment. Their beliefs about their ability to eventually be successful are critical, but their beliefs about why they were not successful are also important. Another related component of perceptions of control is learners' mindset (Dweck, 1986). Mindset refers to an individuals' belief that intelligence is something you build (incremental) or something you inherently have (fixed). Learners with an incremental mindset and belief in their eventual success will persist and take more risks such as trying challenging problems and employing more advanced cognitive strategies (Dweck, 2006).

Policy Alternatives for Promoting Learners' Optimal Cognitive and Motivational Strategy Development

Policies directed toward learners. With regard to educational policy directed toward learners, two aspects should play a key role in the development of those policies. First, it is crucial that strategies are taught explicitly in the domains for which they are relevant, a key element that has support going back a few decades (e.g., McKeachie, Pintrich, & Lin, 1985). In some domains, such as reading, policy and standards emphasize cognitive strategy development – such as the Common Core Teaching and Learning Strategies in the United States (NGACBP & CCSSO, 2010), more so than in other domains. To a lesser extent, domains of writing and mathematics have begun to focus more on these cognitive strategies over the last decade as well (e.g., NCTM, 2015). However, even in these cases where some strategies are taught explicitly, there has been less emphasis on the adaptive and flexible use of these strategies that match their development as predicted by frameworks such as Overlapping Waves Theory (OWT) and the Model of Domain Learning (MDL) and their associated empirical evidence. Moreover, while *cognitive strategies* are explicitly taught, *motivational strategies* are not addressed in most educational policies as essential aspects of the curriculum. Thus, students are not exposed to strategies that can help them regulate their own strategy use and ultimately, their own learning.

Second, given the evidence from OWT and the MDL, policies should consider that learners' cognitive and motivational strategy development takes time and will likely occur at different rates across learners and contexts as a result of those learners' knowledge, interest, and experiences.

One particular policy barrier – particularly in the United States and Great Britain – to the development of these strategies is educational policy related to assessment. These issues are two-fold and relate to *what* is being assessed and the degree to which there is flexibility in assessment outcomes across learners.

With regard to *what* is being assessed, policies related to summative assessment (i.e., assessment designed to measure learning *after* instruction is complete) focus primarily on the accrual of declarative knowledge (e.g., knowledge about facts), rather than strategic knowledge – both cognitive and motivational. Since learners (and their teachers) are often evaluated on the accrual of this type of knowledge, it is no surprise that learners' time is devoted to this declarative knowledge. Educational policies – and in particular assessments of educational progress – should put more emphasis on the strategic knowledge that will allow learners to obtain more knowledge, rather than on what they have accrued during the course of a semester or year. This includes both the cognitive strategies to accrue that knowledge *and* the motivation necessary to employ those cognitive strategies.

Formative assessments (i.e., assessments designed to measure learning during the course of instruction) should also focus on strategy use as well. Formative assessments (the term in the United States) and assessment for learning (i.e., teachers and students working together to better understand student achievement, such as in New Zealand; Hume & Coll, 2009) can be key to helping students use their strategic knowledge adaptively and flexibly. Formative assessment, and to a greater degree, assessment for learning enables learners to receive more timely and useful feedback to monitor, control, and regulate their own strategy use (Dinsmore & Wilson, 2016).

In addition to rethinking *what* is being measured, educational policy should also reexamine the speed of strategy development and the amount of variability expected across learners. Particularly, the United States and Great Britain have seen a steadfast emphasis in educational policy on standardized assessment of declarative knowledge following the reauthorization of the Elementary and Secondary Education Act in 2001. This wave of accountability reform in the US and elsewhere shrank the variability in educational attainment – and certainly did not improve it (Nichols, Glass, & Berliner, 2006). And due to the inability of standardized assessments to measure strategy use, the reforms did not consider that different student experiences and interest might lead to different rates of the accrual of declarative knowledge. While we agree with the central goal of that reauthorization and subsequent reauthorizations to improve educational outcomes and opportunities for children who are disadvantaged, the policy had the unfortunate consequence of not focusing on systems (e.g., assessment systems) that measure crucial aspects of learners' development – i.e., cognitive strategies and the motivation to use them.

Seeking to create environments that support critical motivations and beliefs for cognitive strategies use, policies can begin with small adjustments to learning materials such as textbooks. Along with instructional materials, information about the relevance (to the students and broader society) of the topics should be consistently and clearly presented. Tasks need to be presented in a manner and at a level to ensure students are not overwhelmed and have a regular opportunity to experience mastery over the content. Finally, the fact that intelligence is developed and not something inherent is a critical theme that should regularly arise and be embedded in the materials to ensure students do not attribute failure to something they cannot change. Each of these small adjustments to existing materials will act as a nudge, supporting students in persisting with strategies when they fail, and trying new strategies as they become apparent.

Policies directed toward teachers. To standardize student learning, many school systems moved toward more standardized instruction. The prevalence of standardized curriculum materials and pacing guides has increased over the past few decades (Bauml, 2015). While reading in particular has focused more on strategy use than most other domains, even here teachers are asked to provide this strategy instruction in an inflexible way. Typically, teachers instruct students in these strategies in a linear manner. For example, a reading teacher might teach a visualizing strategy in one week, a keyword strategy the next week, and so on. However, available scientific evidence would suggest that the use of these strategies is not linear and, therefore, teaching them in this manner is not congruent with optimal strategy development. Rather, instruction and use of strategies needs to be taught more flexibly.

Fortunately, new empirical evidence based on naturalistic decision-making models can help researchers – and more directly teachers – think about how their strategy instruction is facilitating students' strategy development and ultimately their learning. Naturalistic decision-making models (i.e., models that focus on individuals' behavior in the specific environments in which they occur) focus on cognitive and motivational functions that are difficult to study in a laboratory setting. While these naturalistic models span disciplines beyond education, a few of these models in education can guide policy and policy-related research. For example, teachers' personal beliefs guide their actions during all phases of teaching and learning (Cornett, 1990). By better understanding how these personal beliefs influence their actions (i.e., personal theorizing), those teachers can better reflect on how their instruction is helping to develop learners' cognitive strategies and the motivation to use them.

In addition, professional development for teachers needs to be focused more squarely on reflection around this issue as well. One well-established avenue uses teacher action research as professional development (i.e., teachers as researchers examining questions in their own particular context; e.g., Levin & Rock, 2003). Programs of action research focused on the topic of facilitating cognitive strategies could help teachers better refine their practice— more so than "canned curriculum" materials that do not address the individual and contextual differences that drive the development of strategies.

While school materials can act as a nudge, teachers have the potential to change students' courses of development. Teachers too often fail to realize their power to affect students' motivations and beliefs. Even as students spend more of their time in online learning situations, the classroom support teachers provide can still be critical to student success (Fryer & Bovee, 2016). Teachers need to be supported in putting students' motivations and beliefs at the center (along with knowledge and strategies development) of instruction. Policy-guided shifts in instruction need not affect what is taught and might only have a tiny effect on how much. For the support of students' motivations and beliefs, how teachers organize and frame materials for students is critical (including assessment as addressed previously).

Studying the Effectiveness of Policies Designed to Promote Optimal Cognitive and Motivational Strategy Development

In addition to helping teachers better reflect on their own practice, naturalistic models can also help researchers understand strategy development in practice, more so than laboratory studies might. These types of studies should not necessarily replace laboratory experiments, however; they are critical to better understanding how the context of schools – and the policies of national and local educational organizations – may change the relations between strategy use and learning.

One potential stumbling block is that strategy use is notoriously difficult to measure (Veenman, Van Hout-Wolters, & Afflerbach, 2006). Strategies have typically been measured either through concurrent reports, such as having individuals say out loud what they are thinking during the task, and surveys have been the most common means (Dinsmore & Alexander, 2012). Concurrent reports are notoriously time intensive to collect, code and analyze, but surveys require specialized skills to interpret and may lack validity evidence with regard to score interpretations.

Thus, researchers should employ measures of strategy-use that are both efficient and easy to interpret, while at the same time provide moment-to-moment information on strategy use that provides valid assessments of learners' strategy use. Many of these measures – and their related interpretations – are in their infancy, but some avenues of exploration are promising. Experience sampling in areas like emotion (Ketonen, Dietrich, Moeller, Salmela-Aro, & Lonka, 2018; Nett, Goetz, & Hall, 2011) and motivation (Rathunde & Csikszentmihalyi, 2005) are steadily opening up new avenues for understanding the pattern of students' experience in and outside of school. Experience measurement potentially may explain the effect of short-term interventions on cognitive strategies and the motivations that propel them. On a larger scale (entire schools or whole districts), experience measurement approaches are also well situated to model the "natural development" of strategies in current school environments. Results from such studies would provide a sound foundation for future development in this area. Such tools are necessary to evaluate educational policies relevant to the instruction of strategies in the classroom in a naturalistic way – both by researchers and the practitioners themselves.

Conclusions

Currently, despite the importance for learners to be able to employ cognitive strategies adaptably and flexibly, educational policy concerning assessment and instruction have not enabled teachers or learners to adequately focus on these strategies or the motivations that propel them. Policies that allow for the growth and development of these strategies and motivations that are matched to the learner and the particular context the learner is situated in can go a long way in helping those learners to acquire these necessary strategies to succeed within particular academic domains. Concurrently, policies also need to allow for more teacher leeway in facilitating these individualized trajectories of student strategy use. Requiring strict adherence to pacing guides is an anathema to the development of a useful array of strategies across multiple domains as well as the development of the motivation to use them. Finally, teachers need to be empowered to examine this strategy development in their own classrooms through action research or other professional development paradigms that allow the teacher to reflect on what works in their own contexts – rather than standardized instruction that is not likely to work for every child.

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