Instructional Implications of David C. Geary’s Evolutionary Educational Psychology

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David C. Geary’s thesis has the potential to alter our understanding of those aspects of human cognition relevant to instruction. His distinction between biologically primary knowledge that we have evolved to acquire and biologically secondary knowledge that is culturally important, taught in educational institutions and which we have not evolved to acquire in modular form, is critical to instructional design. In this article, I outline some of the instructional implications that I believe flow from Geary’s theory.

David C. Geary’s distinction between biologically primary and biologically secondary information constitutes an advance that is rare in our discipline. For researchers in instructional psychology, the distinction adds a major piece of the jigsaw puzzle on which we are all working. In the process, Geary has provided a theoretical framework that has the potential to resolve important issues with profound instructional implications.

For several decades, the dominant theoretical framework of instructional psychologists has been various versions of a discovery learning/constructivist teaching paradigm (Kirschner, Sweller, & Clark, 2006). Although this framework can probably be sourced back to philosophers such as Dewey or even Rousseau, in more recent times, Bruner’s (1961) advocacy of discovery learning can be considered as the origin of the current movement. In its modern versions, it was suggested that because learners must construct their knowledge of the world, we should not present them with information transmitted from a teacher to a student but rather learners should as far as possible and within limits be permitted to construct that knowledge without unnecessary impediments associated with receiving knowledge from others.

For several decades and for good reasons, this argument has been dominant. Although there are many causes for that dominance, one obvious cause stood out: Outside of educational/instructional contexts, we do acquire huge amounts of information without explicit instruction or, indeed, any discernible instruction whatsoever. The manner in which we learn to speak provides one of the most startling examples of our ability to discover large amounts of complex knowledge without explicit instruction. We learn how to simultaneously arrange our lips, tongue, breath, and voice simply by immersion in a listening/speaking society. That learning is unconscious, effortless, and rapid. Not only is the knowledge acquired at a very young age without teaching, but most of us would have little idea how to teach someone to speak their native language.

It was both easy and sensible to observe the ease with which humans acquired large amounts of knowledge outside of educational contexts and the difficulty many people had in acquiring considerably less knowledge within educational contexts. The logical conclusion seemed to be that this distinction was caused by the artificial and inappropriate procedures used to teach. If the same procedures were used within education as were used in the external world, it was quite reasonable to assume that learning could be equally as effortless and effective. This rational argument seems to have implicitly driven instructional procedures in all curriculum areas. Although there are signs of a current backlash, it is probably accurate to say that this paradigm is still dominant.

Why has there been a backlash? Although the rationale made sense as a hypothesis, despite decades of effort no large body of empirical evidence based on randomized, controlled experiments supporting constructivist teaching procedures has emerged with no credible body of evidence supporting the procedure. If anything, the evidence points in quite the reverse direction. When dealing with novices in a domain, there are an overwhelming number of studies demonstrating that learners provided with worked examples to study learn more and perform better on tests than learners asked to solve the equivalent problems (see Renkl, 2005). This effect, called the worked example effect, has been demonstrated on innumerable occasions around the world. It directly contradicts...
the suggestion that students will learn more if they are asked to discover something for themselves, in this case a problem solution, rather than being presented with the relevant information by an instructor.

At this point, those of us associated with theories such as cognitive load theory (e.g., Clark, Nguyen, & Sweller, 2006) that were constructed around the empirical evidence associated with effects such as the worked example effect were faced with a conundrum. On one hand, there was overwhelming evidence that learners could acquire immense amounts of information outside of educational institutions, largely without explicit instruction. On the other hand, when we ran instructional experiments using commonly taught educational materials, the results strongly indicated that far more was learned using explicit instruction. For this researcher, working within a cognitive load theory framework, there was no obvious resolution to the contradiction.

Geary’s thesis has provided the required resolution. In the process, theories such as cognitive load theory, designed to generate novel instructional procedures, have been considerably strengthened. By introducing the distinction between biologically primary and biologically secondary information, Geary has explained why learners can acquire some information easily and unconsciously, indeed, are strongly motivated to acquire such information, whereas other information can be acquired only with considerable conscious effort, often requiring external motivation. Instructional procedures that assume learners can acquire biologically secondary knowledge by “immersion” (Kirschner et al., 2006) in the same way as they can acquire biologically primary knowledge flow, at least in part, from our previous failure to distinguish between these two categories of knowledge. When dealing with biologically secondary knowledge we have neither the motivational impetus nor the genetically inspired ability to assimilate information automatically. We require explicit instruction and motivational encouragement. Neither is required when dealing with biologically primary knowledge.

Since Geary’s formulation, it has become clear that theories like cognitive load theory apply solely to the biologically secondary knowledge for which schools and other educational institutions were invented. The cognitive architecture on which the theory is based (Sweller, 2003, 2004; Sweller & Sweller, 2006) applies to the wide variety of knowledge dealt with in educational contexts rather than the specific knowledge addressed by modular, biologically primary systems. That architecture assumes that most human cognitive activity is driven by a large store of information held in long-term memory; that most of that information is obtained from other people by imitating, listening, and reading; that problem solving in novel domains is heavily influenced by a random generate and test procedure; that novel information is processed by a limited capacity, limited duration working memory; and that there are no working memory limitations when working memory deals with familiar information from long-term memory. In various forms, these principles have constituted a cognitive architecture that has been used in the generation of a variety of instructional procedures (Sweller, 2003, 2004).

From Geary’s work it has become clear that some of these principles either do not apply or only distantly apply to biologically primary knowledge. For example, a large store of information in long-term memory is equally important for either primary or secondary knowledge. In contrast, although working memory limitations when acquiring novel information are critical to secondary knowledge, those working memory limitations seem to be less important when acquiring novel primary knowledge. The modular systems for acquiring primary knowledge seem to permit huge amounts of information to be rapidly assimilated with a working memory load that is considerably reduced compared to the cognitive load imposed by biologically secondary knowledge. Children learn the prodigiously complex motor movements associated with speaking their native language with relatively little apparent strain on their working memory.

Similarly, the modular primary knowledge systems are organized to acquire knowledge without the random generate and test that is characteristic of human problem solving. The term “problem solving” seems to apply only to secondary knowledge. We do not puzzle over how to proceed when acquiring our native language or learning to recognize faces in the typical manner associated with solving, for example, problems in a biologically secondary knowledge domain such as mathematics. The random generate and test process that is central to problem solving when dealing with novel, biologically secondary knowledge is irrelevant to novel, biologically primary knowledge because we have evolved to respond appropriately when dealing with primary knowledge. We do not have to test which responses might be appropriate in a given environment because we are genetically programmed to consider only a very narrow range of possible responses. That genetic programming is unavailable when dealing with the biologically secondary knowledge characteristically relevant in education-based environments.

It should be noted that the aforementioned principles used to describe human cognitive architecture when dealing with the secondary knowledge relevant to education, apply equally to the constructs of evolution by natural selection (Sweller & Sweller, 2006) and, in that sense, constitute a natural information-processing system. Until relatively recently, evolution has been largely ignored in the field of psychology and has been quite irrelevant to educational psychologists. It is easy to assume that evolutionary principles have no significance when dealing with instructional design. In fact, there is a clear link between instruction and evolution via two steps. The first step involves a link between instructional procedures and cognitive architecture, whereas the second step involves a link between cognitive architecture and biological evolution.

With respect to the first step, instructional procedures that fail to take human cognitive architecture into account are likely to be random in their effectiveness. Too many
instructional design recommendations seem to proceed as though human cognitive architecture does not exist. The near universal recommendation that we should teach for understanding rather than rote learning provides a case in point. Most of us concerned with instructional issues subscribe to this recommendation. Nevertheless, we are far too happy to recommend that instruction should facilitate “understanding” rather than “rote learning” without ever indicating which aspects of human cognitive architecture are involved in understanding or rote learning. Frequently, there is an assumption that although rote learning clearly requires long-term memory, understanding is somehow unrelated to memory. In fact, both are critically dependent on the existence of a long-term memory store.

As an example, if we rote learn that $3 \times 4 = 12$, we can store that rote-learned fact in long-term memory. If, in addition, we not only learn that $3 \times 4 = 12$ but also understand that multiplication means repeated addition so that $(3 \times 4) = (3 + 3 + 3 + 3) = 12$, then we have gone a small way toward understanding the meaning of multiplication. Nevertheless, this additional information also must be stored in long-term memory if understanding is to occur. Further understanding of the concepts associated with multiplication requires additional storage of information in long-term memory. The difference between learning by rote and learning by understanding is not that one requires information to be stored in long-term memory whereas the other does not. Both are equally reliant on the storage of information in long-term memory. It is the nature of the information stored that distinguishes between the two forms of learning. Learning with understanding requires large amounts of linked information (called high element interactivity information by cognitive load theorists) to be stored in long-term memory. Processing novel, linked information in working memory imposes a heavy cognitive load, and so many learners will rote learn instead. It does not follow that learning with understanding somehow reduces the role of long-term memory or, for that matter, working memory. The only difference is that learning with understanding results in more information being stored in long-term memory and that information has characteristics that make it difficult to process in working memory. When dealing with biologically secondary knowledge, human cognitive architecture is central to all forms of learning and should not be ignored by instructional designers.

Relations between instructional procedures and cognitive architecture provide a first step in linking instruction to evolution. Relations between cognitive architecture and biological evolution provide the second step. Human cognitive architecture presumably evolved in the same way as all other biological structures and functions evolved. If, to continue the aforementioned example, we describe “understanding” in terms of long-term memory storage and processing in working memory, we can provide potential evolutionary mechanisms by which human “understanding” could evolve. Why did we evolve with a vast long-term memory associated with a limited working memory when dealing with novel information? Why did we evolve so that the limitations of working memory disappear when it deals with familiar information from long-term memory? If we wish to place an emphasis on understanding rather than rote learning, what are the instructional implications of these cognitive characteristics?

Any proposed mechanisms that relate instructional design to cognitive architecture on one hand and cognitive architecture to biological evolution on the other hand may or may not be valid but they are potentially describable. In contrast, if a frequently used term such as “understanding” is left undefined as it is in many instructional recommendations, it merely becomes mystical. We are all in favor of learning with understanding rather than rote learning, but if we do not define what we mean by learning with understanding in a manner that is intelligible from an evolutionary perspective, we run the risk of providing a framework that encourages the use of almost any instructional procedure including ones that are most unlikely to be effective. Our ability to “understand” has evolved in the same way as any other human function, and there is an onus on instructional designers to explain what they mean by understanding and how their concept of understanding can be incorporated into a human cognitive architecture that evolved according to the precepts of evolution by natural selection.

Geary’s evolutionary educational psychology with its emphasis on modular primary knowledge that we have evolved to acquire, and more general secondary knowledge that has become culturally important but for many people frequently difficult to understand, provides us with a firm foundation for instructional design. For those of us involved in instructional issues, I believe the advantages of his approach should be immediately apparent.

REFERENCES