

Discussions

Crystallized Intelligence: The Value of Factual Knowledge in Theory and Practice

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This Discussion argues that technological advances do not diminish the value of factual knowledge and crystallized intelligence in education and everyday life. Learning factual knowledge has been undervalued, but that this knowledge is a prerequisite for higher-level cognitive engagement. Additionally, technological developments, like Google and artificial intelligence, have led some people to believe that learning facts is an obsolete goal of education. However, learning factual knowledge builds crystallized intelligence, which facilitates high-level problem solving, fosters creativity, and even increases fluid intelligence. The benefits of high crystallized intelligence also help with passive learning, which can aid in functioning in everyday life. The overall lesson of this Discussion is that crystallized intelligence remains valuable, even in a technological environment that makes information easy to access.

In education, factual knowledge is often downplayed. Teachers and schools in the United States eschew rote memorization and proudly state that they “Teach students how to think, not what to think.” Educational theorists criticize teaching factual knowledge, calling it “drill and kill” and often linking it to an excessive focus on increasing standardized test scores (e.g., Mitchell, 2007; Simpson, 2015). Recent technological advances, such as Google and artificial intelligence, have made it more challenging to justify teaching facts; with so much information at one’s fingertips it is reasonable to ask whether there needs to be much information inside one’s head. Students, teachers, and others may legitimately question the value of learning factual information if anyone can easily look up information at any time.

In this article, I argue that the mastery of factual knowledge is still a valuable goal for education because it builds crystallized intelligence. I also explain how a strong foundation of factual knowledge is a prerequisite for higher-level thinking and creativity. Finally, I discuss how growth in crystallized intelligence can build fluid intelligence, thereby helping thinkers move beyond facts and into more abstract thinking.

The Nature of Crystallized Intelligence

Decades of research and theory from cognitive, educational, and differential psychologists show the value—both in the classroom and in everyday life—of learning facts. Experts in intelligence would explain these benefits via the concept of crystallized intelligence. Here, “crystallized intelligence” refers to the store of knowledge, information, and ability applied to familiar contexts (often developed

through experience and training). In contrast, fluid intelligence is a general reasoning capacity that is often measured with tasks requiring problem solving with neutral or unfamiliar stimuli (Cattell, 1943, 1963; McGrew, 2009). The bifurcation of intelligence into fluid and crystallized intelligence has been a useful one for research (Schroeders et al., 2016).

The concept of crystallized intelligence overlaps—but is not synonymous—with the concepts of declarative knowledge and factual knowledge. Declarative knowledge is knowledge that can be verbalized, such as instructions for cooking a family recipe. Factual knowledge is a subset of declarative knowledge and consists of knowledge about facts, such as the capital of Venezuela. It is the factual knowledge aspect that has been disparaged in education and sometimes overlooked in research. But factual knowledge is a vitally important concept, both in research and everyday life. This importance is demonstrated, for example, in the appearance of measures of factual knowledge appear on many intelligence tests, especially in the form of vocabulary and information subtests. These subtests are measures of breadth of intellect—as opposed to the level of one’s intelligence that is measured in subtests (such as matrix reasoning) that require examinees to solve increasingly difficult problems (Jensen, 1970/1973).

Breadth of knowledge provides learners with many benefits. First, interrelated facts are the building blocks for a framework for understanding a topic, as humans assemble the information into a mental model called a *schema*. As a learner’s schema grows more detailed and elaborate, it becomes easier to learn and retain new information (Jung et al., 2022; Thorndyke & Hayes-Roth, 1979). In other words, a deeper understanding of a topic is dependent on having

knowledge about it first. Broader foundational knowledge also allows a person to have more schemas, which leads to a deeper understanding of many topics and makes sophisticated interdisciplinary thought possible. This is one reason why the typical behavioral geneticist has insights into both biology and behavior that the average biologist or psychologist does not, for example.

Another cognitive benefit of crystallized knowledge is that it reduces demands on working memory. Cognitive psychologists have long understood that the capacity of working memory is limited (Miller, 1956). Information in long-term memory—often in the form of crystallized intelligence—can be recalled to assist in the process of conscious problem solving. This recall process permits users to deal with much more information than they could by relying solely on working memory (Baddeley, 2003, 2012). People with more factual knowledge, therefore, often have an advantage in problem solving.

Educational psychology theories also implicitly endorse the importance of factual knowledge and crystallized intelligence. One of the field's mainstay theories is Bloom's Taxonomy, illustrated in [Figure 1](#). In this venerable classification of learning outcomes, recalling facts is one of the most basic forms of learning. While most educators want their students to ascend the hierarchy and have a deeper understanding of the course material, this is not possible unless a student first can recall facts and basic concepts about the discipline. Bloom's Taxonomy explains why constructivist teaching techniques, like discovery learning and inquiry-based teaching fail so miserably in elementary and middle schools (Hirsch, 1996; Kirschner et al., 2006). Children simply do not have the knowledge and information necessary to reach more advanced levels of understanding. Even novice adult learners often struggle with constructivist teaching. If teachers want their students to reach the higher levels of Bloom's Taxonomy—applying, analyzing, evaluating, and creating—then teachers must first ensure that their students have enough knowledge to engage with the class content on a deep level. Although it is not the most glamorous part of teaching or learning, sometimes factual learning requires rote memorization and “drill and kill” instruction. Learning the multiplication tables, a foreign language, the periodic table of elements, or human anatomy simply requires committing facts to memory and being able to recall them on command. Rote memorization and “drill and kill” instruction are a highly efficient learning method for mastering this type of material.

Just as it is difficult to reason in-depth about a topic without knowing a lot about it, it is also challenging to engage in creativity without factual knowledge. Contrary to popular belief, creativity is not a unitary construct (Baer, 2022), which is likely why popular creativity tests fail to show any coherence in their factor structure (e.g., Warne et al., 2022). Creativity is, instead, domain-specific, and being creative in a domain requires knowing a lot about it: what problems exist, previous solutions that have been inadequate, past innovations, the standards of excellence in the domain, etc. In other words, to be creative in a discipline, a person first needs factual knowledge about it, which is why

the relationship between domain knowledge and creativity in the same domain are positively correlated (e.g., Meier et al., 2021) and why people with more knowledge in a domain can produce creative ideas that are more useful (e.g., Ward, 2008).

I am not arguing that rote memorization and committing facts to memory should be the only or best educational outcome. Creativity, high-level learning, and other high-level cognitive outcomes are wonderful goals for educators and society, and keeping students in the realm of learning facts will prevent them from experiencing these valuable outcomes. Constructivist teaching techniques have their place in the education system. Indeed, scientific training at the graduate level consists of a great deal of constructivist education (even if the faculty usually do not call it that). Educators and society should foster such complex learning, but learning domain content is a prerequisite for successfully scaling the heights of Bloom's taxonomy.

Likewise, there are some academic skills that cut across domains. Persuasive writing, logical reasoning, and research skills are valuable in many different domains. Nonetheless, they still require information about each skill (e.g., accepted grammar, syllogisms, evaluating resources) in order for these cross-disciplinary skills to fully develop. In other words, even domain-general skills require mastering specific foundational facts and information.

Modern technology can make it tempting to bypass the tedious, mundane practice of learning factual knowledge. However, Google and artificial intelligence do not provide an escape hatch from learning facts or building crystallized intelligence. Most fundamentally, neither Google's search algorithms nor artificial intelligence models prioritize truth. This means that both always have the potential to mislead. If a web page containing erroneous information receives a lot of incoming links, then Google will display it higher in search results. If incorrect information is widespread, then large language models trained on that inaccurate information will reproduce it (Warne, 2024). Users with high levels of factual knowledge will have an advantage over others in identifying correct information and avoiding incorrect conclusions.

Factual knowledge is also important for individuals to function well in society. For example, civics knowledge is important for casting an informed vote and resisting simplistic political narratives. High crystallized intelligence also helps people in abstract communication, such as using and understanding irony, metaphors, and allusions to the shared culture (Hirsch, 2006). A reference on television to Juliet on her balcony or “star-crossed lovers” assumes that viewers recognize the phrase or know who Juliet is. Perhaps that is why the Wechsler Intelligence Scale for Children—Revised included the question, “Who wrote *Romeo and Juliet*?” on its General Information subtest. Necessary cultural knowledge is not confined to “highbrow” content and scholastic learning, though. “Lowbrow” culture contributes to it through the mass media, and a person with high crystallized intelligence living in the United States is more likely to understand allusions to the *Infinity Gauntlet*, “chaotic good,” or a rose ceremony.

Bloom's Taxonomy

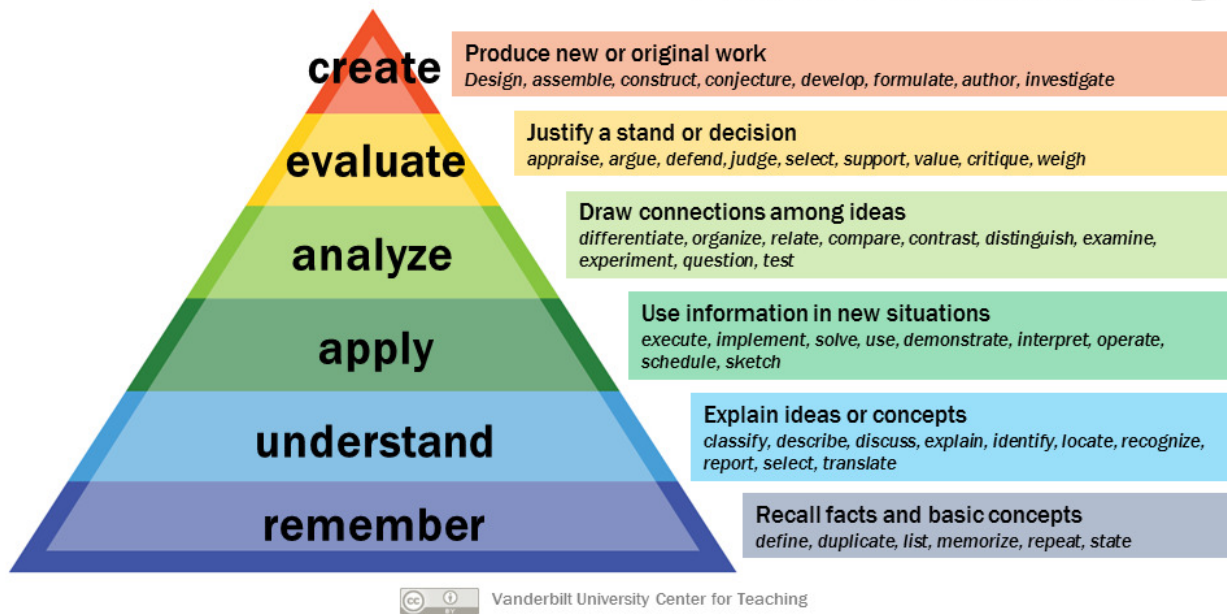


Figure 1. Bloom's Taxonomy

Note. The most basic level of understanding consists of recalling facts and basic concepts. This ability is a prerequisite for learning at higher levels. Image source: Vanderbilt University Center for Teaching, <https://www.flickr.com/photos/vandycft/29428436431>. Creative Commons license CC BY 2.0.

These examples demonstrate how crystallized knowledge is built outside of the classroom. Schools do not teach children about the Marvel Universe, Dungeons and Dragons, or *The Bachelor*. Yet, people understand the allusions because they have been exposed to these concepts, often repeatedly, even if they have never played a game of D&D, watched a Marvel movie, or seen an episode of *The Bachelor*. A similar phenomenon occurs with vocabulary knowledge, which is an excellent measure of intelligence (e.g., Canivez et al., 2020; Frisby & Beaujean, 2015). Most words that people know were not learned explicitly by intentionally memorizing a definition. Rather, people ascertain the meaning of a word as they are exposed to it in the context of the language of everyday life (Gottfredson, 1997; Jensen, 1980). The more often a word occurs in the lexicon, the more opportunities a person has to understand and learn its meaning. Smarter people need fewer exposures to a new word—on average—to learn its meaning. A similar phenomenon occurs with factual or cultural information: while some is learned in school (such as the author of *Romeo and Juliet*), much of it is learned through exposure—and smarter people gain more through that exposure.

Ironically, it is fluid intelligence that encourages people to learn factual information from everyday experience and build their crystallized intelligence. Divining the meaning of a word from context clues or assembling new information into a schema requires using one's fluid intelligence. But once enough facts about a topic are stored in a person's long-term memory, a cycle begins where crystallized intelligence can spawn improvements in fluid intelligence as

concrete examples and information prompt insights into general principles. After learners have reached a sufficient level of fluid intelligence, they can use that fluid intelligence to engage in creativity, complex learning, and knowledge generation. Fluid intelligence begets crystallized intelligence, which begets more fluid intelligence (Cattell, 1963; Lohman, 2006).

And so, the discussion of crystallized intelligence comes full circle, from the theory of fluid and crystallized intelligence to the benefits of crystallized intelligence in the laboratory, the classroom, and everyday life, and back to the relationship between fluid and crystallized intelligence. Of the two constructs, fluid intelligence has received much more attention from psychologists (Lohman, 2006). But fluid intelligence has been harder to alter through explicit instruction, while crystallized intelligence is more amenable to teaching. Crystallized intelligence is a valuable psychological construct in its own right, and understanding, and building, this can provide benefits to researchers, educators, and the public. Information has never been easier to access than it is now, but that has not reduced the relevance of crystallized intelligence or the benefits of ensuring that all learners have sufficient knowledge for their future educational and career success.

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