FOUNDATION FOR INNOVATION

RESOURCE

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Learn with Joy. Live with Purpose.

THE FOUNDATION OF **REAL INNOVATION** IS DEPTH, BREADTH & INTERCONNECTIVITY OF **KNOWLEDGE.** THE QUESTION IS, WHAT KNOWLEDGE MATTERS?

"Would you have ever learned or discovered anything, if you had not been willing to learn from others?"

—from Plato's *The First Alcibiades*
(Plato, c.350BC/2015, p.12)

Every house needs a foundation. Every leap forward first needs firm footing; every aspiration needs a launch pad. This RESOURCE TOOL is designed to provide and explain the three foundational building blocks needed for developing real innovation in education, business and life.

The foundational building block that is still needed for innovation is KNOWLEDGE: depth, breadth & interconnectivity of knowledge. The question is, what knowledge matters most?

DEPTH & BREATH OF KNOWLEDGE

A great deal of ink has been spilled, megabytes of data have been filled and considerable "air time" has been given to twenty-first century skills—and rightly so. Our culture, our society and our economy are changing rapidly as the years roll on into the second millennium and as the Age of the Internet takes hold is all areas of human endeavor. As education moved from "information scarcity" to an abundance of information, teachers became less concerned about "what to teach" and more interested in developing the skills needed to develop flexible and innovative learners for the new millennium. The shift from content-based education to skill-based education, however, had begun decades earlier.

John Dewey (1902) rightly observes, "It is certainly futile to expect a child to evolve a universe out of his own mere mind" (p.13). Learners must begin with what they know, and set out to build on that knowledge: "nothing can be developed from nothing" (Dewey, 1902). This is where educators—as facilitators — play a necessary role in the process of education. Teachers guide learners to new opportunities and new knowledge, and they help learners determine sub-goals, means, and methods to achieving their ultimate goal.

With so much information freely available online and with so much uncertainty about what information learners, entrepreneurs and others will need in the future—many educational and business pundits have argued that specific knowledge acquisition doesn't matter as much as skill development.

In truth, depth of knowledge may matter even more in the age of information abundance. Daniel Boorstin (1984) states that "The greatest obstacle to discovery is not ignorance, it is the illusion of knowledge."

Boorstin highlights one of the emerging consequences of the so-called "Age of Information"—that is, because of the plentiful and easy access to information (on a superficial level), many people can create an illusion of knowledge. This means that expertise matters even more today than perhaps ever before. Historically, there would always be someone who knew a lot about a little; today, everyone can know a little about a lot. The differentiator for the twenty-first century and for fostering innovation is to have both: to know a lot about a little while also knowing a little about a whole lot. Being truly knowledgeable is more important because ignorance can be masked with superficial understandings that have been cherry-picked from the World Wide Web. Innovative learners need to be able to do three things well with their knowledge: (1) they need to be able to contextualize what they know, (2) they need to bridge their expertise with other knowledge and other experts and (3) they need to apply their understanding in new ways.

WHY KNOWING IS STILL NEEDED

Isaac Newton, one of the great English physicists of the seventeenth century, famously remarked on the source of his ability to discover new theories and innovate new technologies: in a personal letter to a competitor he writes, "if I have seen further, it is by standing on the shoulders of giants" (Newton, 1675). The millennia old aphorism used by Newton underscores the essential ingredient to new discovery, creativity and innovation: a foundation of knowledge is needed for innovators to build upon.

Famous innovators like da Vinci and the Wright brothers tackled the problem of "heavier than air flight" by taking stock of what they knew.

Figure 1: detail from da Vinci sketch book on the principles of flight; "Mechanical Wing Device" ca. 1485

"Knowledge is paradoxically both empowering and entrapping. It depends on the problem. And sometimes enough expertise can even get one past a trap" (Perkins, 2000, p.214).

"In the play of the mind, ignorance is usually a villain. It is not good not to know. Information is the fuel for the mind's explorations" (Perkins, 2000, p.214).

WHAT KNOWLEDGE IS NEEDED?

Leonardo da Vinci understood how birds achieved flight "not just by flapping but by riding up ramps of air" (Perkins, 2000, p.3). By analogy, he applied the principle of the "screw" to flight and he designed the world's first (theoretical) helicopter. The design, however, wouldn't work because of other factors such as size and weight of the machine and the increased power source needed for flight (i,e., smaller and lighter objects, like insects and birds, require less energy to achieve flight).

The Wright brothers further developed da Vinci's idea of the "air screw" by applying what they knew about bicycles, nautical propellers and bird wings to invent powered flight. The result was a "wing-propeller analogy," which led to "one of the last major breakthroughs necessary" for flight (Perkins, 2000, p.5).

The point of these two examples is to show how previous knowledge coupled with new applications resulted in real innovation. Perkins book, *The Eureka Effect*, examines the art and logic of breakthrough thinking: he writes, "Information is the fuel for the mind's explorations" (Perkins, 2000, p.214). But information for information's sake is not the end goal and doesn't—on its own—led to real innovation.

Too often the content knowledge of curriculum focus on what Barab and Dodge (2008) call "disembodied" data; "facts are torn away from their original place in experience and

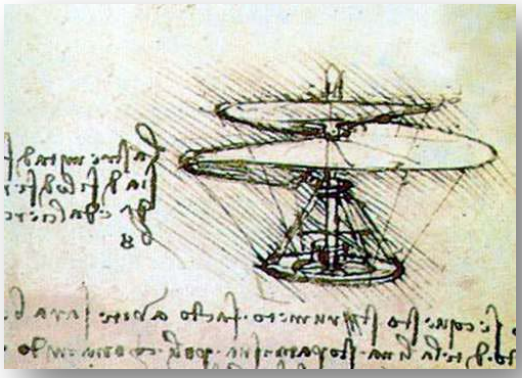


Figure 2: detail from da Vinci sketch book; "Aerial Screw" ca. 1485

rearranged with reference to some general principle" (Dewey, 1902, p.6). Instead, the learner needs to see the skills and information within the broader context of their own learning and the context of the world.

Learners still need what innovators Kinsman and Ko (2017) call the "fundamentals of knowledge." Innovators not only bridge certain knowledge with other acquired knowledge (like da Vinci and the Wright brothers), but they also challenge the fundamental knowledge. But, as Kinsman and Ko state, "students first need to know something before they can challenge it" (Kinsman and Ko, 2017).

FUNDAMENTAL KNOWLEDGE

From historical anecdotes of innovation, we see that fundamental knowledge is needed for new ideas to germinate. This includes expertise or depth of knowledge. The famous "10,000 hour rule" has been discussed by psychologists and authors (cf. Chapter 2 of Malcolm Gladwell's *Outliers,* 2008) in terms of skill development; however, it also applies to knowledge acquisition. Through extended practice and deep learning, innovators like Bill Joy (inventor of the Internet) and Bill Gates (founder of Microsoft) were equipped for innovation by their knowledge expertise. Both these men spent "10,000" hours learning about computer technology and accumulating deep knowledge of how and why the technology works. This foundation allowed them to innovate in new, previously unimagined ways.

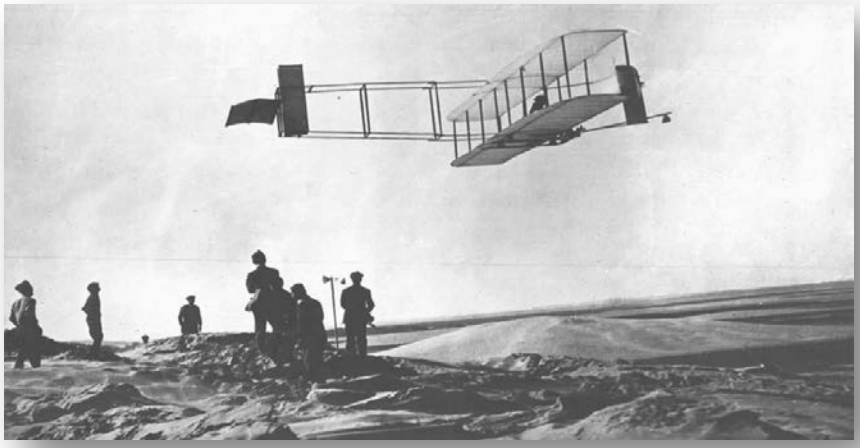


Figure 3: Soaring flight, by Orville Wright, Kitty Hawk, NC, Oct, 1911.(10469 A.S.)

INTERDISCIPLINARY KNOWLEDGE

So much of the curricula "content" learners encounter in school becomes an objective unto itself. Egan states, however, that "the point of education is not the achievement of some objective but is rather a quality of engagement with the world" (Egan, 1988/1999, p.157). Egan further refers to Whitehead (1929), who "stressed the uselessness of being merely well informed, of having accumulated endless 'inert' knowledge." (Egan, 1988/1999, p.158). The learner cannot create an alternative reality; he must discover the one that is there. This comes by connecting what he or she knows with new ideas and new knowledge.

In Zhao's "Catching Up or Leading the Way" (2009), he states that the new knowledge students need is that which is required to live in a "global world and the virtual world" (p.151). He provides examples of the kinds of knowledge schools should teach: "foreign languages, global awareness, multicultural literacy, and knowledge to cope with the global world" (p.151).

Again, the goal is not to focus on discreet knowledge alone (although this may be initially necessary to develop expertise): the greater goal is interconnectivity. But how can we make knowledge constructs more interdisciplinary? Fadel et al., (2015) explain that interdisciplary connections are natural but often obscured. The concepts need to be developed in more overt ways: "Because knowledge can transfer beyond disciplines, it is natural to consider the ways that connections with other knowledge areas can be made explicit" (p.80). An example of this is provided by Fadel, et al. (2015): "exponentials (from mathematics) can be taught alongside compound interest (from finance) and financial bubbles (history, sociology), as well as bacteria growth (biology) and resource exhaustion (environmental literacy)" (p.80). In arguing for an overhauled curriculum, Fadel, et al. (2015) propose that "new, modern interdisciplinary subjects, branches, and topics, focused on essential concepts, meta-concepts, methods, and tools with cross cutting themes need to be included in students' education to equip them with knowledge necessary for the twenty-first century" (p.84).

KNOWLEDGE AND COMPETENCY IN 21st CENTURY SKILLS

The foundation for innovation couples both knowledge—that is, depth, breadth and interconnectivity of core, fundamental knowledge—with competency in twenty-first century skills. What exactly those skills are various from source to source. The main source of variation, however, seems to come from terminology and categorization and less about disagreements as to what sort of skills are needed. Below I have provided a sample of twenty-first century skills as articulated by Stratford High School, a public school in Connecticut (2017).

The category "Collection of Information" may be relabeled on a different list as "Research Literacy" or "Information and Technology Literacy"—all three monikers, however, imply the same sort of skill. The key is to achieve "competency" in these areas.

Competency education has been gaining increased awareness, and rightly so. The current employment climate is showing that credentials do not necessarily show competency, only the ability to complete educational tasks. But it is impossible to have skills without content. This has been brought to the attention of educators especially in the field of literacy: in recent decades, literacy was taught primarily as a skill along with numeracy. Literacy—particularly in the area of reading—however, is not only a means to gain content knowledge, it requires *prior knowledge* in order for true comprehension to occur, opening the door for new ideas. Blauman (2011) calls "background knowledge… the 'hook' to hang new learning on" (p.85). She states, "Without that 'hook,' learning often doesn't 'stick' with students" (p.85).

KNOWLEDGE and COMPETENCY

Collection of Information

- Access information
- Organize information
- Evaluate sources
- Use information
- Align solution with task
- Cite all sources accurately

Collaboration

- Show independent initiative
- Assume shared responsibility
- Assist others in their roles
- Contribute ideas
- Keep an open mind
- Apply strategies
- Take a variety of roles
- Tolerate different viewpoints

Communication

- Listen actively
- Express ideas
- Use a variety of techniques
- Select appropriate media
- Use multiple forms of media

Creativity

- Know personal creative process
- Generate ideas
- Maximize creative efforts
- Demonstrate originality
- Learn from mistakes

Critical Thinking

- Ask clarifying questions
- Analyze complex systems
- Evaluate evidence
- Justify arguments
- Draw conclusions
- Reflect on learning
- Transfer problem-solving skills

Character

- Show consideration
- Respect everyone
- Show concern for others
- Embrace diversity
- Maintain positive values

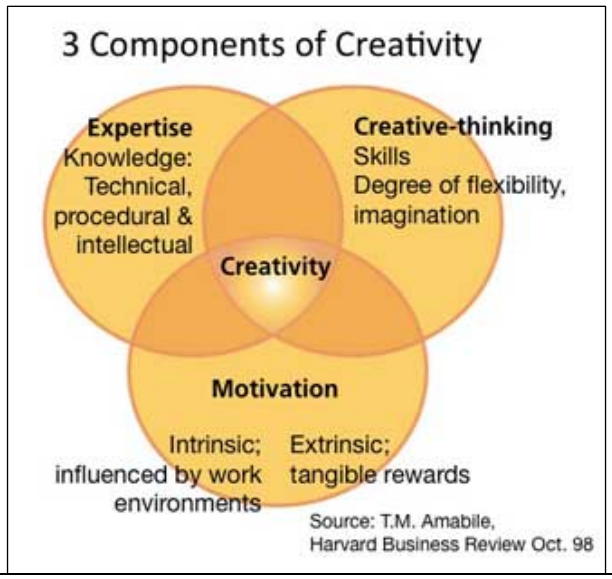
To open up the doors for improved literacy, but also for increased opportunities for innovation and the creation of new knowledge, Chrys Dougherty (2014), ACT senior research scientist, writes

> *Teach a content-rich curriculum in the early grades. Ensure that all students receive a content—and vocabulary—rich curriculum beginning in the early years, spanning a range of subject areas including not only English language arts and mathematics, but also science, history, geography, civics, foreign language, and the arts.... Such a curriculum—the basis for preparing students long term for college, careers, and informed citizenship—is valuable for all students but is likely to be especially beneficial for students from at-risk demographic groups, who are more likely to arrive from home with limited knowledge and vocabulary* (p.28).

"Expertise encompasses everything that a person knows and can do in the broad domain of his or her work. Take, for example, a scientist at a pharmaceutical company who is charged with developing a blood-clotting drug for hemophiliacs. Her expertise includes her basic talent for thinking scientifically as well as all the knowledge and technical abilities that she has in the fields of medicine, chemistry, biology, and biochemistry. It doesn't matter how she acquired this expertise, whether through formal education, practical experience, or interaction with other professionals. Regardless, her expertise constitutes what the Nobel laureate, economist, and psychologist Herb Simon calls her "network of possible wanderings," the intellectual space that she uses to explore and solve problems. The larger this space, the better" (Amabile, 1998, n.p.).

In the United States, the controversial "Common Core Standards" have sought to articulate essential content needed for success. E.D. Hirsh, author of *Cultural Literacy: What Every American Needs to Know* (1987), played a significant role in moving American education in this direction. Although there are no "silver bullets" or panacea solutions for education challenges. As one proposed solution fails to address *all* the problems within education, new gurus arise proposing new solutions. Mainstream adoption ultimately supplants the previous ideas until it too fails to address all educational woes. In the process, good ideas and good approaches can get lost. I fear with the rise of twenty-first century skills, the area of "cultural literacy" and fundamental knowledge may too disappear. Kirby (2013), in his essay "What Sir Ken Got Wrong" criticizes the work of Sir Ken Robinson on emphasizing "creativity" over "content." He cites global educational expert Oates (2013) who explains that "In all high-performing systems, the fundamentals of subjects are strongly emphasized, have substantial time allocation, and are the focus of considerable attention." Similarly, Christodoulou (2012) writes that "thinking skills are subject-specific; our working memories are limited and easily overloaded by distractions; and pupils are novices" as opposed to "experts, and so require expert guidance" (Kirby, 2013, n.p.).

Harvard business expert, Teresa Amabile, is also the expert on fostering creativity in business contexts. She has identified "three components" of creativity: (1) Expertise (2)Creative thinking skills and (3) Motivation (Amabile, 1998, n.p.). A lot of attention has been placed on "creative thinking skills" and "motivation" but very little attention has been devoted to "expertise"—this is simply described as "knowledge" by Amabile (1998, n.p.).



PUTTING KNOWLEDGE IN ITS PLACE

(OR, WHY CONTEXT MATTERS AS MUCH AS CONTENT)

Because of the plethora of information so readily available to students, teachers are no longer "gate-keepers" and conductors of a limited resource. As Scott McCusker writes,

> There's almost an over-abundance of information. A class of students could easily collect and process 100 potential sources in a single class. They can access materials from different eras and regions. They have access to experts and their work. It's becoming common for actual artifacts to be available online; and in many cases, replicas of artifacts can even be downloaded and reconstructed with a 3D printer (2014, n.p.).

With so much information, students can feel lost and overwhelmed. What information matters and what doesn't? This is where the teacher plays a vital role. The teacher's job in the age of Information Abundance is to provide survey-like overview to contextualize information. Context facilitates student interest, helps establish links with prior knowledge and provides students with a meaningful environment for them to go deeper and explore further.

MOTIVATION

Dewey (1902) argues that "somehow and somewhere motive must be appealed to, connection must be established between the mind and its material" (p.27). He says this because "The subject-matter does not appeal; it cannot appeal; it lacks origin and bearing in a growing experience" (Dewey, 1902, p.7). The motivation to learn the "nuts and bolts" of a subject—the motivation to set sail on the educational journey—is to have a bearing and context for the skills and content within a larger and meaningful framework.

PRIOR KNOWLEDGE

Context helps students organize their learning and add the new knowledge to their growing level of expertise. Hirsch write, "Experts in any field learn new things faster than novices do, because their rich, highly accessible background knowledge gives them a greater variety of means for capturing new ideas" (1999, p.23).

ANTIDOTE TO MYOPIA

Knowledge within its context is helpful when going deep. Context is an antidote to intellectual myopia and facilitates analogizing and innovating as well as interdisciplinary thinking.

PRIOR KNOWLEDGE

"Psychological research has shown that the ability to learn something new depends on an ability to accommodate the new thing to the already known. When the automobile first came on the scene, people called it a 'horseless carriage,' thus accommodating the new to the old. When a teacher tells a class that electrons go around the nucleus of an atom as planets go around the sun, that analogy may be helpful for stuednts who already know about the solar system, but not for students who don't. Relevant background knowledge can be conceived as a stock of potential analogies that enable new ideas to be assimilated. Experts in any field learn new things faster than novices do, because their rich, highly accessible background knowledge gives them a greater variety of means for capturing new ideas. This enabling function of relevant prior knowledge is essential at every stage of learning." (Hirsch, 1999, p.23).

TEACHER AS CONDUCTOR IN THE CLASSROOM ORCHESTRA

"One analogy for the role of the teacher in an abundant economy of information is that of the conductor. The conductor stands before the class and uses the individual performances of the students to produce a broader more powerful work. At various times during the group's 'concert,' the conductor may call attention to the work and talents of different individuals. Throughout the lesson, different sections of class work are highlighted, helping to set the overall tone of the lesson. The smaller contributions of the students are melded into the greater whole. Soloists may have a moment to shine, but the work is constructed from the entire group. The conductor may never play a single note, but his understanding of each small part of the larger work makes a far more powerful product possible" (McCusker, 2014, n.p.)

If KNOWLEDGE is essential for innovation, what knowledge matters most? How can educators know what to leave in and what to leave out? Without compromising academic excellence or devaluing the traditional knowledge that underpins all achievements of human civilization, how can educators effectively manage and use KNOWLEDGE in 21st Century Learning? Or, as Fadel et al., ask, "How does one *carefully* pare back pieces that are less relevant, to make room for the learning of modern knowledge areas and competencies required for the twenty-first century?" (Fadel, et al., 2015, p. 77). Here are five ways schools and educators can examine "any given discipline in order to identify its essential components" (Fadel, et al., 2015, p.77).

1. CONCEPTS AND METACONCEPTS

A discipline can get bogged down in the minutiae of its subject area. Fadel, et al. ask "What is essential to a given discipline? What are the ideas that students will carry with them throughout their lives, either due to direct practical value or enrichment of worldview?" (2015, p. 77). "Concept" can be defined as an abstract idea or general notion. Without a knowledge of a particular concept, it is impossible to move to deeper understanding or more complex tasks within a certain discipline. Not everything students learn in history or math class is essential; those concepts that are essential, should be retained. The example given in Fadel, et al., is the mathematical concept of "rate of change"—the rate of change concept, however, has multiple applications within mathematics and also beyond mathematics; this is referred to as a meta-concept: "meta-concepts are concepts that are inherently overarching across the discipline and sometimes beyond to other disciplines" (2015, p.78). The indispensability of a concept or its iniquitousness within its discipline (or across disciplines) means that it must be retained and taught.

2. PROCESSES, METHODS AND TOOLS

Another area to evaluate curriculum content and help answer the question what knowledge matters is to determine what processes, methods and tools are indispensible. “Processes are the big picture elements of every discipline, and will vary widely from field to field” (Fadel, et al., 2015, p.79). Methods refer “to reasoning skills within a given discipline” that learners must possess and know in order to apply in various ways. Tools are the “granular types of methods” students must know, such as the multiplication table (p.79).

3. BRANCHES, SUBJECTS AND TOPICS

Educators can begin evaluating overlap between subjects and identify emerging (and more relevant) subtopics within a discipline. We cannot retain branches, subjects and topics simply for the sake of nostalgia. Discernment and evaluation is needed. Less relevant topics, for example, may need to give way to new and emerging topics within a discipline. Or, educators may wish to create more space in the curriculum by delegating topics to other disciplines. Such changes may be very difficult within a provincial or state regulated curriculum.

“With the arrival of the Information Age, both the amount of new knowledge produced, and the ease of accessing this knowledge, expanded exponentially. New and more innovative knowledge maps are now needed to help us navigate the complexities of our expanding landscape of knowledge” (Fadel,et al., 2015, p.74)

4. INTERDISCIPLINARY APPROACHES

Fadel, et al., (2015) observes that "highlighting interdisciplinary applications of concepts, meta-concepts, methods and tools can be a powerful way of illustrating concepts and making them immediately relevant to students" (p.80). The more ubiquitous an aspect is, or the more readily applicable to other disciplines may prove to be another effective filter for what to teach and what not to teach.

More collaboration and cross-pollination between disciplines is greatly needed to help streamline the redundancies and even help identify gaps in students content knowledge and skill development. Discipline specific aspects and discrete elements still have merit. The caution with interdisciplinary ventures is to avoid losing depth. Nevertheless, if students find applications between content and skills learned in multiple subjects, their engagement and empowerment will be enhanced. But what about the "essential" knowledge and skills needed for professional expertise down the road?

5. "ESSENTIAL" FOR WHAT PURPOSE?

Mathematics and science teacher have some of the most "bloated" curricula in all of education. Educators frequently lament in Ontario, for example, about the simple fact that there is too much to teach. The most difficult aspect of this dilemma is that all the information has the potential to be useful and indispensible. "Cognitive scientists have long recognized that the key to acquiring knowledge and mastering skills is to possess a considerable amount of background knowledge" (Willingham, 2009 as cited in Munson 2011). Students need to "know" enough information in order to learn more. The question of how much to do we need to teach is answered—in part—by the second question: for what purpose? Fadel, et al., (2015), writes that "we will never be able to know all of the specifics of a given subject, especially because our understanding will continue to change. […] Learning as much of the specifics as possible should not be the goal of teaching a particular subject in school" (p.81). Not every student will become an expert, so why prepare them to be one?

References

Amabile, T. (1998). How to Kill Creativity. Havard Business Review. Retrieved June 08, 2016, from https://hbr.org/1998/09/how-to-kill-creativity

Barab, S., & Dodge, T. (2008). Strategy for designing embodied curriculum. In Spector J. M., Merrill M. D., Merrienboer, J. V., Driscoll, M. P. (Eds.), Handbook of research on educational communications and technology. (3rd ed., pp. 97-110). New York, NY: Lawrence Erlbaum Associates.

Bergin, C., & Bergin, D. (2009). Attachment in the classroom. *Educational Psychology Review, 21(2),* 141-170.

Blauman, L. (2011). "Building a Better Book Club." Comprehension Going Forward. Portsmouth, NH: Heinemann.

Dewey, J. (1902). The child and the curriculum. Chicago, IL: University of Chicago Press.

Goulart, M. I. M., & Roth, W-M. (2010). Engaging young children in collective curriculum design. Cultural Studies of Science Education, 5(3), 533-562.

Fadel, C., Bialik, M., & Trilling, B. (2015). Four-dimensional education. Boston, MA: Center for Curriculum Redesign.

Hirsch, E.D. (1999). The Schools We Need and Why We Don't Have Them. New York: Doubleday.

Kirby, J. (2013, October 12). What Sir Ken Got Wrong. Retrieved August 11, 2017, from https://pragmaticreform.wordpress.com/2013/10/12/what-sir-ken-got-wrong/

Munson, L. (2012). What Students Really Need to Learn. *Educational Leadership*. pp. 10-14.

Phillips, D. C. (1998). John Dewey's The Child and the Curriculum: A century later. The Elementary School Journal, 98(5), 403-414.