Google “brain games for kids” and you can find apps, board games, puzzles, phonic fun, improvisational games—the list goes on and on for all ages in a billion dollar market. But questions remain: do toys and games improve thinking or IQ, or do they just make a child better at playing the games? Our authors examine the market and give us an inside look at some of the research behind this billion-dollar industry.
In 1954, Walt Disney was the first to envision a new form of entertainment that melded traditional fun and education—a form that he dubbed “edutainment.” By the latter part of the 20th century, this form had morphed into educational toys and games, a multi-billion-dollar industry that is projected to capture a full 36 percent of the global toy market share by 2022.

Nowhere is this trend more apparent than in the explosion of digital apps: of the 2.2 million apps available in the Apple Store, roughly 176,000—8.5 percent—are loosely designated as “educational.” Their growth continues, with annual increases of 10 percent expected through 2021. Whether called edutainment, educational toys, or the digital learning revolution, this trend shares the implicit philosophy that mixing fun and learning will offer a kind of “brain training” that will enhance children’s thinking and amplify their learning potential.

But there are many questions before us. What do manufacturers and marketers mean when they designate a product “educational?” What relevant research in the science of learning has been done? Is there a standard definition of educational value that guides the field? Indeed, a framework we use highlights when toys might sculpt mental muscle and when products are likely to be total imposters. This framework helps us elucidate which educational and digital toys are likely to confer benefits for children.

If humans learn through a socially sensitive brain, and there is much evidence that they do, then the best brain training for young children might be human-to-human interaction of the sort that is typically sacrificed when children sit alone with “brain training” toys. At this frontier, educational toys and games that balance fun, social, and learning—that prompt social interaction rather than providing a substitute for it—might improve brain training.

What is an Educational Toy or App?
Remarkably, the term “educational,” as used in regard to educational toys and games, is essentially a marketing ploy rather than a meaningful designation. Put the alphabet atop a rocking chair, and the piece of furniture proudly wears the title of “educational.” Add a number game to your app and
you are teaching math - again, “educational.” The term is unregulated and there is little quality control among such toys.

Playing with construction toys like LEGO, Mega Bloks, or Magna-Tiles, for example, builds spatial competencies that foster strong science, technology, engineering, and mathematics (STEM) skills. In fact, 3-year-olds who are more adept at copying a model block arrangement have better spatial skills and math skills when they begin formal schooling. Yet, most such toys do not appear in the educational aisle. Instead, we are apt to find a flash card app game that asks a child to “find the square” amidst two side-by-side geometric shapes, followed by clapping sounds or “try again,” which hardly inspires learning. Again, the adjective “educational” is not very instructive when used in the context of toys or apps.

**Separating the Wheat from the Chaff**

In recent years, companies like Lumosity, Jungle Memory, and CogniFit have offered their own versions of neuroscience-you-can-use. One such product, LumiKids, introduced in 2015 and owned by Lumosity, offers an example of an educational app advertised to help train young brains that failed to fulfill that promise. In January 2016, the “brain training” parent company Lumos Labs paid $2 million to settle a claim for false advertising. On May 23, 2018, its LumiKids division—with game and workout apps for children—closed its webpage.

LumiKids highlights the critical problems parents and educators have in determining which “brain training” products are good, and which are not. One solution is to inform our choices with the help of gatekeepers like Common Sense Media, an organization that lists products that pass muster as brain trainers and warn us of those that fall short.

A more far-sighted way is to impress on the industry that the science of learning can guide the creation of products that might truly exercise the brain and build strong learners. Taking this second route, Hirsh-Pasek, Zosh, and colleagues combed the scientific literature to determine what we knew about the way human brains learn, and distilled five characteristics that could be assessed in a toy, app, or program to promote stronger learning. We learn best, they found, when the process is
active, not passive; engaging, not distracting; meaningful, not divorced from everyday meaning; socially interactive versus solo; and when there is a clear learning goal.

Research from a variety of fields, including psychology, cognitive science, education, and neuroscience, supports the validity of these principles. Based on them, we can create what Hirsh-Pasek, Zosh, and colleagues called “profiles and pedigrees for learning” with which we could rate any toy or app. Indeed, Radesky and colleagues are now converting these principles into a formal method to assess the educational value of apps currently on the market. The same method should work for toys, both digital and non-digital.

**What Works**

Educational toys and apps may be categorized as cognitive, motor, and collaborative. They are also often divided by marketers into categories, such as app-enabled toys, screen-less toys, toys to life (doctor sets), puzzles, and building games. And some toys and apps definitely do meet the criteria set forth above and do stimulate learning to a greater or lesser degree.

Construction toys, for example, have been consistently popular in the educational toy marketplace, and research suggests that children do learn while engaged with them. Why? Because they embrace the five pillars that support strong learning. For example, block building with toys like LEGO is active, engaging, meaningful, and socially interactive (though blocks can be used alone). While they do not always have an explicit learning goal in mind, blocks are fundamentally STEM toys that invite children to rotate pieces, align edges, and notice shapes. Levine and colleagues found that young children who play with blocks and with related STEM toys like puzzles demonstrated better spatial transformation ability than their peers who do not.

Construction toys like blocks not only engender this kind of STEM play but may also build narrative skills as a child constructs King Arthur’s castle, complete with a moat. These are good examples of brain-training toys that are not, for the most part, explicitly branded as such—nor need they be digital, though there are some examples of digital block play.
Word games like Scrabble Junior” and Boggle Junior teach children how to rearrange word parts into more sophisticated units of meaning. Mackey and colleagues\(^6\) found that children who played such games, in both digital and non-digital formats, improved their fluid reasoning or processing speed, depending on the type of training to which they were exposed.\(^5\) These games meet the criteria of active, engaging, meaningful, and social, with an added element of competition that might also relate to increased motivation for learning,\(^6,7\) as well as creating a joyful attitude towards learning.\(^8\)

Certain apps have similarly been proven to spark learning. A body of research conducted on the game Tetris demonstrates how a tile-matching puzzle video game play can improve mental rotation and spatial visualization abilities.\(^9,10,11\) And there is a rich body of work examining “Minecraft,” a game in which players mine and build different types of three-dimensional blocks. Thanks in part to its limitless possibilities for individualized experiences, Minecraft has been used to teach spatial geometry,\(^12\) language and literacy,\(^13\) and ecology,\(^14\) among other topics. The active, engaging, meaningful, and socially interactive features of this game serve the goal of refining skills through problem solving.

While toys and apps like those described above have earned their shelf space as potential brain trainers, others fall short. The iPotty, which features a tablet holder attached to a child’s training toilet, was named the Worst Toy of the Year in 2013 by the Campaign for a Commercial-Free Childhood. Toys like these reinforce the idea that children need to be entertained every second of the day, even while using the bathroom.

As a less extreme example, electronic toy sorters have also been weighed in the research balance and found wanting as promoters of children’s development. The version described by Zosh and colleagues\(^13\) featured five blocks (circle, square, triangle, star, and heart) and a series of holes to put them in.\(^15\) It also had light-up headlights, three musical piano keys, and buttons that audibly said “stop,” “go,” and “slow down,” when pushed. A plastic dog moved from side-to-side when the toy was moved. The study found that parents used more spatial language—shape words like “triangle” and “square” and direction and position terms like “over” and “under”—with their children when
playing with a shape sorter without the bells and whistles that characterized the electronic version. And research finds that spatial language improves later mathematical skill.

Rethinking Brain Training for Children

Clearly, educational toys, apps, and games vary widely in quality. To find which should be considered effective requires that we stretch the traditional categories of brain training. In the adult literature, recent reviews define brain training in terms of the narrow slice of products that offer training regimens said to increase speed of processing, memory, and attention. Through this narrow lens, the growing consensus is that brain training has limited utility.

In our view, brain training helps adults—especially older adults—respond more quickly and efficiently on precisely the tasks that they practice. That is, the literature suggests that if you use memory enhancing apps, you will likely increase your memory span to similar tasks. The latest reviews of this literature, though, suggest that you get no transfer from tasks designed to promote better speed of processing. That is, tasks that enhance speed of processing build speed of processing but do nothing to foster memory skills.

There are many ways to exercise the human brain and many ways to support diverse outcomes. Mental gymnastics of the brain training variety are possible and also probable if toy and app designers are clear about the learning goal (e.g., STEM, language, processing speed) and if they employ the characteristics of strong learning a la active, engaged, and meaningful social features.

Our framework for top educational toys, apps, and games, however, also sneaks in what might become a critical part of the brain-training equation: human-to-human interaction. Surely, children can engage in solo learning, and many do as they sit contentedly in front of a book, a screen, or a model LEGO castle. Yet today, children are spending more and more time alone. The latest statistics suggest that 43 percent of children ages 8 and under are likely to own a digital device, a number up 12 percent from 2013, according to Common Sense Media. Further, children who are age 8 and younger spend three hours a day in front of a screen without an adult or a social partner. We have yet to learn the consequences for brain training in this more isolated social context, although a
major long-term study, the A.B.C.D. Study (for Adolescent Brain Cognitive Development), funded with $300 million from the National Institutes of Health, aims to provide some answers.

Meltzoff and Kuhl are among those that argue that humans learn best through a socially primed brain—i.e., when engaged with other people. Chi also suggests that social interactivity is a key ingredient for learning—a property that we enlisted in our framework for how to construct the best educational toys, apps, and games. This does not mean that learning cannot be accomplished without social input, but that engagement with social partners enhances the process.

In one study, 2-year old children were asked to learn two new words. They learned them perfectly when engaged in fluent conversation, but not so well when they sat before a televised display. They also learned these words superbly in a fluid video chat conversation, although the interchange existed only on a two-dimensional display. It was similarly found that infants learned some of the sounds in Chinese when the language was presented with a live person who spoke Chinese and not when they heard the exact conversation televised. Further, when parents are interrupted with a cell phone conversation, their children do not engage and fail to learn words that were being taught just before the cell phone call. Socially engaged interaction seems critical to brain training for these younger children.

Research suggests, similarly, that the social aspect of playing with toys, games, et cetera, has a role in brain development. Such experiences may help children develop what scientists term proactive control, which reflects neural mechanisms in the prefrontal cortex that take information from the environment and make determinations about what might happen next. Adult, or more knowledgeable peer support, may be the mechanism through which children develop proactive control, because such interactions fuel learning through playful exchanges.

Some “educational” toys, however, thwart the kinds of playful interactions thought to be so important for brain development. Sosa, for example, noted that 18-month olds did not play as well with toys that had electronic features and no social input. Indeed, parents felt locked out of the play experience because the toys commanded so much attention. And Zosh and colleagues found
that using the electronic shape sorter resulted in parents relying more on the toy for entertainment instead of engaging their children in conversation.15

These examples provide only a small sample of what appears to be a potential problem in the development of “brain training” toys. As more and more companies try to create digital components and even digital friends to replace real human-to-human interaction, alarms should be sounding. True educational toy, apps, and games—especially for younger children—require social partners as a part of the experience.

**A Way Forward: Brain Training 3.0**

If active, engaging, meaningful, and socially interactive toys/apps and games with learning goals can build brains, perhaps companies can engineer products that accord with the characteristics that support strong learning. Might designers build social interaction into block play, puzzle play, and even digital play? Some innovators are, in fact, doing just that: one new product, “Osmo,” created a tablet that facilitates multiple player collaboration.

Bottom line? “Brain training” is a catchy phrase introduced not by scientists but by marketers hoping to capitalize on the commercial value of learning. There are some examples of “brain training” in the scientific literature, but it is not well studied and not strongly supported at this time. Sadly, the term brain training has become a cliched adjective often appended to products designed to stimulate learning. The very best brain training toys, however, are those that require children to be active, and that are engaging, meaningful, inspire social collaboration, and that have a clear learning objective.

Scientists can work with designers to help them develop products based on the best science of learning. When this cross disciplinary synergy becomes more common, brain training can flourish both in and out of school. While there is surely a place for flying solo in learning, teachers and classrooms dominate the educational landscape because our evolution was molded on a social model. In this digital age of screen-based isolation, our best course is to find ways to re-insert social interaction into our children’s brain training regimes. Only then will we adapt such regimens to the socially primed developing brain.
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