Emerging Technology and Toy Design

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There is an important distinction between a toy and a toy product. A toy is an object that is used for play. A spoon can be used as a toy. A box can be used as a toy. A 3D printer can be used as a toy. But none of these items are toy products. A toy product is an item that is intentionally designed, manufactured, and sold for the primary purpose of play. A tinkerer can make a toy in his basement with an Arduino or a similar device. There are many resources available for tinkering, such as instructables.com or Make magazine, which show people how to “hack” or prototype some exciting toy concepts. These, however, are not toy products, because they are not intended for manufacture and sale. This chapter targets designers who want to work in the toy product domain, not the toy hacking domain. Toy hacking has no restrictions and thus one can almost use any emerging technology imaginable when the intent is not mass production. I am also distinguishing toy products from video games; these are separate markets. For those who want to bring toy products to market, there are several barriers of which you need to be aware. Let’s dig in and begin investigating.

The Challenge of Toy Design

Designing in the toy industry is more difficult than one might expect given its playful nature. There are several reasons for this:

- In addition to the form, function, and manufacturability concerns that are inherent in all product design, toy designers have two customers: the adult caregiver/purchaser and the child/end user. These two customers tend to have very different needs and preferences.
• Toys are required to pass a variety of international safety standard tests related to choking hazard, sharpness, magnets, chemicals, moving parts, strangulation hazard, projectiles, drowning hazard, and so on. Often, every piece of a toy must undergo a series of these tests to prove that the product does not represent a threat to a child's safety in any of these areas.

• The toy industry is seasonal and experiences the largest amount of sales during the holidays. Most revenue is generated in Q4. Popular trends/brands/properties/characters are constantly changing, so the timeline from concept to shelf is very tight if you want to have a new product ready for the holiday season. This seasonality also makes it difficult to plan inventory and get realistic feedback during the year.

• Toys are inexpensive. Very few toys are at a price point comparable to a consumer electronics item. As children grow older, they become interested in different things. Their skills and abilities change and therefore they regularly desire new and different toys. The purchasers are aware of this, so the price they expect to pay for toys is typically lower than that of other consumer goods. The relatively expensive toys that are marketable tend to be large (for example, ride-on vehicles) or electronic gaming systems that are not typically considered toy products.

• Currently, there are not many toy company options for licensing ideas. In the 1970s there were many medium-sized licensing manufacturers, but the large toy companies (Hasbro and Mattel) purchased them. Similarly there are fewer small-sized toy retailers today than there were in the 1970s. This makes it more difficult for an independent toy inventor to get their product onto store shelves.

To overcome these challenges, toy designers must innovate robust, low-cost products that appeal to both children and adults in a short amount of time to keep up with a rapidly changing market.

How does emerging technology fit into this design challenge? Often, it does not. This is an artifact of two of the aforementioned issues: time and money. Although there are a variety of exceptions, which we will cover in this chapter, toys are generally not using what would be called emerging technology. The toy industry might be utilizing new
manufacturing practices or materials, but it is not common to walk into a toy store to find an emerging technology that was recently highlighted in a scientific journal or magazine.

**Toys and the S-Curve**

The S-Curve refers to the general shape formed by plotting a technology’s performance over its lifetime. There are typically four main phases of a technology life cycle (see Figure 10-1). The first phase is when the technology is emerging through research and development. In the second phase, the use of the technology is growing in the marketplace and it is becoming widely accepted. The third phase is maturity, in which growth slows down, the technology is widely understood, and few new players join the market. The final phase is the decline of the technology, which is typically the result of a newer technology replacing the utility of the original technology. These stages are sometimes referred to by different names, but the general concept remains the same.

![Figure 10-1. A technology's life cycle: the S-Curve](image)

In the Toy Product Design class I created and taught at both the Massachusetts Institute of Technology (MIT) and the University of Minnesota (UMN), the students take their own toy ideas from concept to functional prototype with the help of children and industry. In these classes the students often try to incorporate technology during the growth stage, such as specialized sensors and actuators that can cost $20 to $30 online. A toy concept might be fun and feasible, but a special part that costs $10 to manufacture might contribute at least $40 to the retail cost of the toy. Will parents want to purchase a toy that costs $100 to $200, particularly if it offers only one type of play pattern? The likely answer is no.
In most cases, toys begin using a technology years after that technology has been moving up the S-Curve of its life cycle. A technology is used when the cost of the manufacture of that component has reached a price point at which it can be profitably incorporated into a toy. Figure 10-2 presents two examples of this dynamic. Of course, this is the case for most consumer products; however, toys are typically on even tighter budgets.

Figure 10-2. Toy prototype examples using mature, inexpensive electronics

As an example, BEAM (Biology, Electronics, Aesthetics, and Mechanics) robotics uses simple parts to produce robots that mimic life. Scientists, engineers, and hobbyists have created human-like robots for years, but
it wasn’t until 2004 when it became affordable enough to mass produce a personal anthropomorphic IR-controlled robot toy such as Mark Tilden’s RoboSapien. Similarly, small motors and microphones existed for a long time before Innovation First released Hexbugs in 2007. The technology was just affordable enough to be profitable when sold inside a $10 toy bug.

This is not to deter designers from experimenting with new technology in toy concepts. It is meant solely as a cautionary note that it might take several years before the technology is inexpensive enough to make a profitable toy product. Toy designers need to imagine how technology that’s emerging today might be incorporated into future playthings when the technology becomes affordable for mass production.

**Toys and Intellectual Property**

The toy industry is a bit like the fashion industry: tastes change rapidly and products have a short life cycle of one to three years. This makes it difficult to protect intellectual property. It might not make economic sense to file a patent to provide a 20-year monopoly especially if it takes 2 to 3 years to prosecute. For example, guitar toys were trendy from 2005 to 2010 with Guitar Hero and Paper Jamz driving sales. If someone had a great guitar-toy concept toward the end of this trend, there would have been no sustainable market by the time she filed a patent. A major exception would be technology that could be used in multiple products or for creating a new product platform.

The overarching point here is that toy ideas from independent inventors do not necessarily need to be patented before licensing to a toy company. Sometimes, this deal between the inventor and licensing company is based more on trust than on concerns over protecting intellectual property.

It is for these reasons that intellectual property in the toy industry tends to take the form of a copyright, trademark, or *design patent* rather than a *utility patent*. A design patent is less expensive and takes less time to file than a utility patent. A design patent protects the ornamental features of the invention, whereas a utility patent protects the functionality of the invention.
A large toy company has the resources and capital to protect all of its new technology; however, a smaller toy company or independent inventor might not have the ability to invest in protecting an idea if the market is erratic and if the patent is not required for licensing. In the past 10 years, Japan is the only country that has filed more toy-related patents than the United States (112,457 versus 52,774) from USPTO. Historically, Mattel holds the most United States toy patents with 4,185; Hasbro has filed 601. Putting this in perspective, these numbers are almost on par with some famous individual inventors—Thomas Edison filed 2,332 patents, and Jerome Lemelson filed 605. Relative to other industries, technology in toys tends to be less protected and the industry puts less emphasis on research and development. Protecting intellectual property usually makes sense in the toy industry only when the toy idea is timeless and one can write broad claims to describe the concept.

**Emerging Technologies in Toy Design**

Even though the toy industry tends to adapt technologies later in their life cycle, there are plenty of examples of emerging technology being incorporated in toys:

- The emerging technology is an accessory to the toy (for example, using a smartphone to control a toy car).

- The emerging technology is affordable enough to be immediately implemented. This includes things we tend to not think of as technology such as a new type of mechanical connector for building blocks.

- The technology might not serve more practical purposes, but is interesting enough to be desired for its playfulness. A great example of this is Silly Putty.

- Novel sensors and electronics are used and the cost reflects the investment. Consider the electronic toys you might find at Brookstone.

- The emerging technology is in the production/manufacturing of the toy (for example, 3D printing).
EMERGING TECHNOLOGY ACCESSORIES

One way toys are using emerging technology is by being an accessory to an established product. Many toy companies do not have the means to move into an entirely new domain, so they adapt their strengths and manufacturing resources to produce a complementary product.

Several companies have developed products that wrap around a smartphone or tablet, turning it into a creature with a screen. The hardware typically comes with a software app that one would download to utilize the previously owned technology product in a new way. Figure 10-3 shows examples of Totoya Creatures “plush toy” accessories that turn a tablet or smartphone into an interactive stuffed animal. (Ubooly is another prominent name in this sector.) The tablet or smartphone becomes the face and brains. This makes it possible for a toy company that once made stuffed animals to now have a product in the consumer electronic aisle.

Figure 10-3. Totoya Creatures are plush monsters that utilize a smart device with a special app

The Disney AppMATes and Mattel Apptivity line of products consist of toys that interface with tablet devices. Users can control the app with a physical action figure as a playful stylus. With these products, users can race a physical car directly on the screen or battle with physical action figures. In the past, video games have utilized physical interfaces outside of a controller (Nintendo Power Glove, Power Pad, and Zapper); however, in these examples, the physical item is not a toy
on its own. Skylanders: Spyro’s Adventure and Disney Infinity have blurred the lines between the video game and toy industries. In the Skylanders and Infinity gaming platforms, the video game has a physical toy component. The user purchases and plays with action figures that are “transported” into the video game world, bridging the gap between real and virtual play. The toy component contains very minimal technology (an RFID chip); the real innovation is in the interaction with the video game.

In these prior examples, the existing smart device is controlled with a physical toy. Conversely, there are examples in which the physical toy is controlled with the existing smart device. There are a number of wireless vehicles such as cars, planes, and helicopters that a user can control with a smartphone (the Parrot AR.Drone, iRemoco, Griffin helicopter, and Rover Spy Tank are all examples). A recent innovation by Orbotix is the Sphero Ball, which is a simple looking sphere that contains internal motors that roll the ball wirelessly with a smart device interface. The physical toys in these examples are a bit more advanced than the RFID or stylus action figures because they both receive and transmit information.

In all of these examples, a smartphone or tablet is the host technology. Smartphones and tablets are likely the most advanced technology that modern families own and entrust to children. However, as technology begins to incorporate into the home and community in new ways, there will likely be other hosts for physical toy accessories.

One concern when designing a toy as an accessory is that the toy’s success is dependent on another company’s platform. The designer has less control over the future iterations. One might release a product to find that it no longer works with the newest platform.

**SIMPLE AND AFFORDABLE EMERGING “TECHNOLOGY”**

Emerging technology in the toy industry might not look the same as emerging technology in medicine or personal electronics.

In 2010, if you were to do a survey of the top 100 best-selling toys on Amazon.com, you would find less than 10 items that contained any electronics. A survey in 2013 revealed that not one of the Amazon.com top 10 best-selling toys contained electronics or even any significantly advanced technology—the top sellers included card games, rubber bands, and injection molded blocks. Popular toys (excluding video
games) tend to be simple, low-tech products such as Silly Bandz or Squinkies. In a culture of video games and smartphones, there is still a market for simple physical play. Even with the popularity of the virtual building block game, Minecraft, sales for low-tech stalwart Lego were up 20 percent in 2013 over 2012. Digital play currently lacks the face-to-face social element and the tangible interaction.

In society today, one can almost view digital toys as a separate market. There is a toy box and there is a smart device. These realms are beginning to collide. What is called a toy today might not what you typically find at a big box retailer such as Toys R Us. Children are playing with tablets, smartphones, and laptops. A smartphone can hold thousands of games (an infinite number, if web based) and many are free. How can the board game industry compete with unlimited and free? One answer is that the physical and social bonding element cannot be replaced with the digital equivalent. Designers are still inventing new types of blocks and sticks and children still want to play with them.

YOXO is a Minneapolis-based company that inspires children to create their own play. There is an old adage that the best child’s toy is a cardboard box. That is exactly what YOXO sells: connectors for toilet paper rolls, boxes of boxes, tubes of tubes, a giant empty refrigerator box, and so on. Sometimes, less technology is less restrictive.

Innovation can be incremental and it can be radical. Incremental innovation is about doing something better, whereas radical innovation is about doing something different. The toy industry tends to be more incremental. Often incremental innovation is more easily assimilated into culture as people can quickly understand and relate to it. From experience talking with toy agents and toy companies, if the idea cannot be explained by looking at a box image for a few seconds or with a 20-second video demonstration, the concept will be more difficult to sell.

As a personal example, in my Master’s thesis at MIT, I designed a bi-stable spring mechanism that can be used to launch foam balls. This technology was used in the Nerf Atom Blaster, but it is not highly visible in the product. The mechanism allows for a slightly different interaction with the toy and a reduction in part count.
Recently, YOXO filed for a patent on a connector design for assembling toilet paper tubes. This technology is the basis for their product line, with which children can construct their own toys with cardboard and other recyclables, as illustrated in Figure 10-4.

In these two toys, there are no cutting-edge sensors or algorithms, but they are both examples of patent-worthy technology that are valuable and innovative in the toy industry. The technology is simple, subtle, and inexpensive. If you visit a toy fair at which industry and inventors are demonstrating and selling new products, the response to emerging technology there is more like, “Why didn’t I think of that?” as opposed to “How did they do that?”
Inherently Playful Technology

Einstein said, “If at first the idea is not absurd, then there is no hope for it.” When one first discovers or invents a new technology the first reaction is likely surprise. It can be confusing at first, and if there is an “Aha!” moment of insight, the surprise could lead to laughter or joy. This is how the novelty of a raw technology itself can be converted into a toy.

In 1943, James Wright combined silicone oil and boric acid to invent a material that behaved as a solid over short periods of time and a liquid over a long period of time. He could not find a market for these unique material properties. In 1950, the search for practical uses ended and it was sold for its playful properties under the name Silly Putty.

More recently, in 2009, Mattel released Mindflex. This is a game that utilizes an EEG (electroencephalography) headset with which a user can control a fan by using brain waves to manipulate a ball in the air. In a sense, the user is controlling a ball with their mind. The toy retailed between $60 and $120 and was successful on its first release in the market. A company called NeuroSky founded in 2004 developed the technology used in this game. Since 2009, the company has applied its technology to applications outside the realm of toys. Mindflex is also used as a platform in the hacker community as a low-cost means of making tools and toys controlled through EEG.

The POPmatrix tongue display unit developed by Aisen Chacin is a grid of electrodes that can be placed on the tongue that allows users to “see” through touch. This is a prototype toy version of a serious invention published by Dr. Paul Bach-y-Rita in 1998 called the BrainPort with which users can see via their tongue by substituting optical nerve input with tongue nerve input. This device when connected with a camera makes it possible for sight-impaired users to visualize a real-time pixilated version of the world in front of them. In this case, a technology that was specifically developed for users with visual impairments had a strong curiosity or “wow” factor that broadened its potential user population.

A designer does not simply sit down and create this type of “tech-wow” toy. These concepts typically start in a research lab in the process of trying to develop something else and the toy product results from serendipity. A designer who does not have a science or engineering background will likely not have the resources to invent new technology;
however, she can always be observant of interesting phenomena in the world. Any naturally occurring phenomena that are surprising or intriguing might be worthy of further exploration.

The downside to “tech-wow” toys is that the wow factor can fade. If the fun is solely in the newness of the technology, eventually it will be less interesting. For example, when Glo Worm (1982) and Teddy Ruxpin (1985) were released they had tremendous a “wow factor” because few stuffed animals could illuminate and talk, but today this technology is commonplace.

**Sensors and Toy Design**

Electronic sensors tend to be what people associate with technology. Sensors are often used to enhance the interaction potential of the toy. If the toy can understand what you are doing, it can respond appropriately and perhaps even learn. This could lead to a more playful experience as the toy can adapt to the user’s abilities to maintain an optimal level of challenge. An optimal challenge is critical for play because it keeps the user engaged.

Sensors can also add functionality, and functionality adds affordances. A toy with more affordances might have more play value because it could allow for more types of play. One can also argue that sensors take away from the user’s ability to design their own play patterns. In any case, as the cost of sensors decrease, we will see more of them in toys. In the future, we might see low-cost (or even free) smart toys for which the cost of the technology is offset by the related digital revenue, similar to how smartphone costs are subsidized by purchasing service subscriptions.

Sifteo is a company founded in 2009 by Dr. David Merrill and Jeevan Kalanithi after leaving the MIT Media Lab. Their product, also named Sifteo, is a gaming platform comprising a set of small blocks with screens (see Figure 10-5), sensors, and wireless communication that gives them the capability to interact with other blocks. There are a number of games one can play on the Sifteo platform with images, words, and video.
In 2011, when the product was finally released, the starter set of three cubes was priced at $149; the following year it dropped to $129. Both the price point and play potential of Sifteo is comparable to electronic gaming systems such as the Nintendo DS, which makes it a more serious and considered purchase than most toy products. In 2010—between the time when Sifteo was introduced at TED in 2009 and its commercial release in 2011—Hasbro released a competing low-cost version of the concept that greatly simplified the play by eliminating some technology, which allowed it to enter the market at a $30 price point.

And yet, Sifteo not only survived this competitive onslaught, it thrived. Why?

One can have a great idea for a new tech-toy, but the price needs to be comparable to the other products that have similar functionality. As a designer, you can try to guide the product to be anchored with a specific category of products, but this is not always in your control. In the case of Sifteo, its toy product was successful at that price point against lower-cost alternatives because it could be anchored with consumer electronics instead of the inexpensive board games.

Kurt Roots and Dr. Monika Heller founded CogCubed shortly after the release of Sifteo in 2011. They realized that sensors in toys might have the ability to understand user behavior. Specifically in the health domain, these sensors can be used to assess and improve cognitive deficits. CogCubed captures data as players manipulate objects, which can be used to create a behavior profile. These profiles can then be used to distinguish abnormalities, but they also can be used to customize
challenges for the specific player. As sensors become more prevalent and interconnected, toys and products in general are going to create more engaging, personalized experiences that have the potential to positively impact cognition and behavior.

There are some open source platforms such as Arduino and LittleBits (Figure 10-6) that make it easy for designers, artists, and tinkerers to create functional electronic toys with sensors and animation. A relatively new sensor that is sold through sparkfun.com is the XBee, which allows your prototype to communicate with the cloud. Imagine designing toys with this technology. Your doll could know more about the world than you do. Websites like inventables.com, sparkfun.com, and instructables.com are great inspiration sources for all designers.

![Figure 10-6. LittleBits are sets of easy-to-use electronic building blocks developed by Ayah Bdeir](image)

### Emerging Technology in Production and Manufacturing

The technology in toys can be showcased (like in Sifteo), hidden (such as my spring mechanism of the Atom Blaster), or it can be the toy itself (such as Silly Putty). Another area in which the technology fits into the toy industry is in the process of its manufacture.

The laser cutter has recently emerged as an integral manufacturing tool in the toy industry. It is a fast, inexpensive, and exact means of cutting thin materials including plastic, wood, fabric, and metal. With advances in technology, smaller toy companies, such as YOXO, and individual toy designers can now afford to own a laser cutter. Consumers are seeing more flat-packed, thin wood toys in gift stores and at toy shows. With this tool, graphic designers who are not trained
in 3D-CAD (computer-aided design) modeling software can now produce physical product with their knowledge of vector-based 2D software such as Adobe Illustrator.

3D printers are also becoming more affordable and faster. In the near future, people will purchase 3D printers similar to the way they currently purchase 2D printers (the cost of the print cartridges will likely be expensive to mitigate the cost of the device). Children and parents can download and print CAD models of physical toys for their children just as they would download a new game onto a smartphone. This is already happening on a small scale with the Maker Bot Digital Store, where children can choose from a set of predesigned action figures to download and print (https://digitalstore.makerbot.com/browse), as shown in Figure 10-7.

In the future, parents and children might play the role of designer by creating new toys and printing them at home. This poses problems. Parents are not exposed to the many quality assurance checks that the toy industry is required to perform on each piece of every toy. One can imagine parents creating toys that are choking hazards or parts that can shear into small sharp points. Parents might embed magnets in ways that allow them to release or create customized projectiles. How can we better prepare ourselves for the future when anyone can be a toy designer with the purchase of an inexpensive rapid prototyping machine?
This future is almost here. Companies such as Ponoko provide the rapid prototyping and 3D printing services. Users can upload their own CAD models for others to purchase. The company prints and ships the model. This is only one step away from a future of home toy production.

**SUGGESTIONS FOR DESIGNING TOYS WITH EMERGING TECHNOLOGY**

1. Imagine the possibilities of current technology when it becomes affordable enough to be applied to a toy. For example, smartwatches that interface with your smartphone have recently entered on the market. Imagine if that technology becomes even more affordable and one can place small sensors with screens around the house that can communicate with one another from a distance. This opens up a realm of toy and game possibilities.

2. If you are developing new technology, keep in mind cost and time. Often incremental innovation is easier to bring to market. The toy industry is like the fashion industry and style changes regularly and rapidly.

3. Make the toy about the play not about the technology. The play that the toy affords should be timeless. The activity should be fun and enjoyable in and of itself. As a designer, use the technology to achieve, enable, or enhance the desired play, not simply provide a “wow” factor. Ask yourself if future generations will still find the toy engaging after the technology is commonplace.

4. Stay informed about new manufacturing processes and rapid prototyping tools. Understanding how toys and products are manufactured will not only make you a better designer, it might also inspire creative ideas.

5. Attend a toy fair. There are a number of toy fairs around the world and they often showcase different vendors. Toy fairs are the conferences of the toy industry where the newest toy products are introduced and presented.
Summary

The role of the toy designer is changing. In the past, toy designers were likely to come from Industrial Design Bachelor of Arts programs, trained to make drawings and foam models. These are still valuable skills, but in today’s society, the industrial designer is also expected to know how things work, how things are manufactured, and how to incorporate electronics, sensors, and new technology. The industrial design discipline is slowly blending with the discipline of engineering design. In academia, this fusion has already begun: there are industrial design degrees that are based in schools of science; there are schools offering interdisciplinary product design degrees; there are graduate programs in industrial design; and there are engineering programs that have product design tracks. In industry, large toy design companies have entire engineering divisions dedicated to research and development. I am hopeful that in the near future, most academic design programs will require a class in computer programming to prepare students for the digital future they will be designing. Although the toy design industry is slow to implement emerging technology, we are always advancing and innovating.