Designing an Exhibit for the Liberty Science Center

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Invitation to Quantum Computing

The purpose of any exhibition, scientific or not, is to educate, to enrich and to provoke thinking. The purpose of science museums is to motivate learning and increase interest in science (Sasson, 2014). The purpose of an exhibition at the Liberty Science Center, according to Lisa Rawson, the Head of the Exhibition Development and Design, is to provide an experience or an opportunity to engage in fun social activity with other members of the group.

The purpose of my exhibition is to spark interest and to extend an invitation to the field of Quantum Computing. The exhibit's aim, although it's a challenge, is to popularize a rather technologically advanced field by including a number of related hands-on activities and explanations and by making it intellectually affordable to all types of visitors (Schwan, Grajal, & Lewalter, 2014). It aligns with the overall mission of the Liberty Science Center, which is "to get learners of all ages excited about the power, promise, and pure fun of science and technology" (http://lsc.org/about-us/history-mission/).

In addition, my exhibition pursues the educational objectives of self-discovery (Sasson, 2014). While participating in hands-on activities, younger visitors may get excited about the topic and, perhaps, continue learning about it after the visit. This objective becomes critically important since the topic of the exhibit involves new technologies. Sparking interest in the topic and planting the seed for the future learning is not only educationally sound (Sasson, 2014), but also relevant.

Another educational element that adds to the strength of this exhibit is its uniqueness. Since there are no similar exhibits available in this region, it will offer some new educational opportunities nonexistent in other museums or science centers (Feinstein & Meshoulam, 2014). In participating in interactive activities and demystifying some concepts of Quantum Computing, the visitors will find the topic approachable, and therefore relevant. Breaking bigger concepts into smaller activities, as directed by Dr. Zieger, makes learning more comfortable, applicable and, therefore, enjoyable.

Needless to say that the popularity of the topic adds to the curiosity about it. Creating an exhibition on the "buzzword" kind of topic makes it intriguing, and more pertinent not only to kids but also to older audiences. It aligns with the overall mission statement of Liberty Science Center and with the educational goal of incorporating learners of ages and educational backgrounds. (Feinstein & Meshoulam, 2014).

Every exhibit tells a story. According to Rawson, the more relevant and compelling the story is, the more time visitors spend at the exhibit. Liberty Science Center design team uses the time indicator, cleverly called "hang time", to measure the exhibit's success. The greater the "hang time" is, the more successful the exhibit is, and therefore, the more effectively it serves its purpose. Below is the story behind my exhibit.

One Bit of Story (Pun Intended)

We might be on the brink of witnessing an important breakthrough related to the processing power of the common computing devices. As our demands for processing power continue to increase and microchips continue to decrease in size, the microprocessor manufacturers are facing serious challenges. Soon they will run no longer be able to decrease the size of microchips any further, limited by their physical properties. Does it mean that the processing power of computing devices will reach its limit and will no longer be progressing? Perhaps. Unless an alternative solution is developed.

An integral part of a microchip, known as a transistor, can hold a value of 0 or 1, or, in physical terms, allow or prevent electricity from flowing through. Modern transistors have gotten so small, that they are comparable to the size of a few atoms. A transistor has scaled down to 14 nanometers. Just to compare, HIV virus is measured to 120 nanometers in diameter, and the red blood cell is measured to 7 micrometers or 7,000 nanometers. It simply means that a modern microchip transistor is 8 times smaller than HIV virus in diameter and 500 smaller than the red blood cell. (https://www.youtube.com/watch?v=JhHMJCUmq28).

The further decrease in size will eventually have to cease, as it will be limited by the physical properties of a microchip. If transistors are getting any smaller, they will no longer be able to hold a charge of 0 or 1, as we know it. Not only that they won't be able to hold a charge, they may start behaving differently, according to the laws of quantum physics (Bachor & Simmons, n.d.). Even with all their processing power, there are some problems that a traditional computer is not capable of solving, but quantum computers can.

While hardware-related technical reasoning for creating Quantum Computers may provide a fascinating story to a technically inclined audience, it may not be as inclusive as the problem-solving approach (Feinstein & Meshoulam, 2014). That's why I plan on opening the exhibition with a series of problem statements.

The Setup

The first part of the exhibition, dedicated to the explanation of exponential growth, will consist of the café-like setting with four coffee tables and two, three, four and five chairs placed accordingly around each table.

All tables and chairs will be bolted to the floor and could not be moved. The first table will have two chairs around it. On the table, there will be a board with the picture of Jack and Jill (the two familiar characters from the Nursery Rhymes) and the following question will be written: "How many different ways can Jack and Jill take seats at this table?" Underneath the board the number two will be written, which is the correct answer. In addition, the two pictures of Jack and Jill will be shown. On one picture Jack will be sitting on the left and Jill will be seating on the right of the table, while on the second picture they will swap their seats.

Right next to it, there will be the second table with three chairs around it. On the table, there will be a board with the picture of Butcher, Baker and Candlestick Maker (the three familiar characters from the Nursery Rhymes) and the following question will be written: “How many different ways can the Butcher, the Baker, and Candlestick Maker take seats at this table?” The answer will be six, and this number will be displayed beneath the question along with the pictures of all six different seat arrangements for the three characters.

The similar setup will continue for the next table, which will contain four chairs and the question to arrange seating places for fours friends. The answer sheet will depict 24 different combinations. The fourth table will have five chairs and will contain the question about arranging seats for five family members. The answer sheet will show all possible 120 combinations. At this point, there will be no more tables and chairs placed, but instead, the display board will show with the following questions: “In how many ways can you arrange seats for six people? What about seven people? Eight? Nine? Ten?“ The following display will provide answers to these questions (See Figure 1-0).

There are 720 different ways to sit SIX people about the table.
There are 5,040 different ways to sit SEVEN people about the table.
There are 40,320 different ways to sit EIGHT people about the table.
There are 362,880 different ways to sit NINE people about the table.
There are 3,628,400 different ways to sit TEN people about the table.

Figure 1-0: An example of an Exponential Growth showing the number of unique seating arrangements around the table.

This is an example for Exponential Scaling, which grows tremendously in the short amount of time. Presently, the classical computer (which is our regular computer) will run out of the processing power required for calculations involving exponential scaling. This is where Quantum Computing can assist. In a classical computer, as we know it, each bit can only take a state of 0 or 1. In a quantum computer, a quantum bit can take a state of 0 or 1, or both at the same time (See Figure 1-1), which is known as a concept of superposition. It means that one Qubit can have the superposition of two states, two Qubits can have the superposition of four states, three Qubits can have the superposition of eight states, etc. (Bachor & Simmons, n.d.) The purpose of this example is to illustrate how powerful Qubits are and to demonstrate that quantum computers are the right kinds of computers to solve exponential growth problems and others of the similar mathematical magnitude. (Kurzgesagt – In a Nutshell, 2015).

Another concept, native to Qubits and related to their behavior, is known as entanglement, In order to illustrate entanglement, the following model will have to be created.

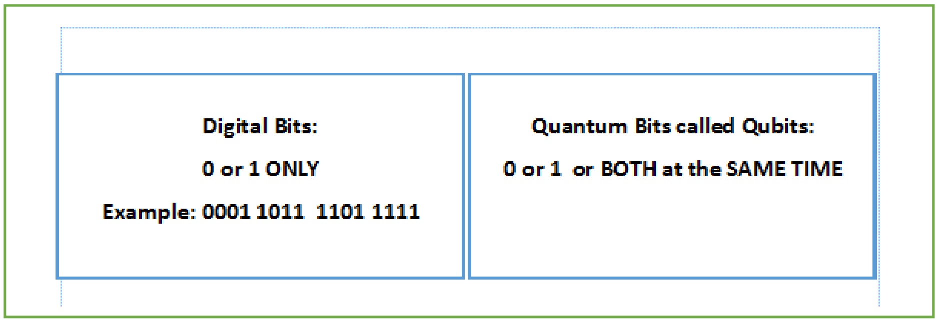

Figure 1-1: Comparison between a digital bit and Qubit values. The explanation of superposition.

The two black, non-transparent cylinders, each of the size of a 3-gallon container, will be placed on the table. The cylinders will be separated by the wall. An LED light will be placed inside each cylinder. Four switches will be placed on the outside on the left cylinder, one for turning the light off, and three for turning the blue, red and yellow lights on accordingly. The right cylinder will have no switches but will be connected behind the scenes with the left one. The left cylinder will have a cover that could be taken off and on. Initially, the cover on the right cylinder will be closed. In order not lose it, the cap will be attached to a string. (See Figure 1-2)

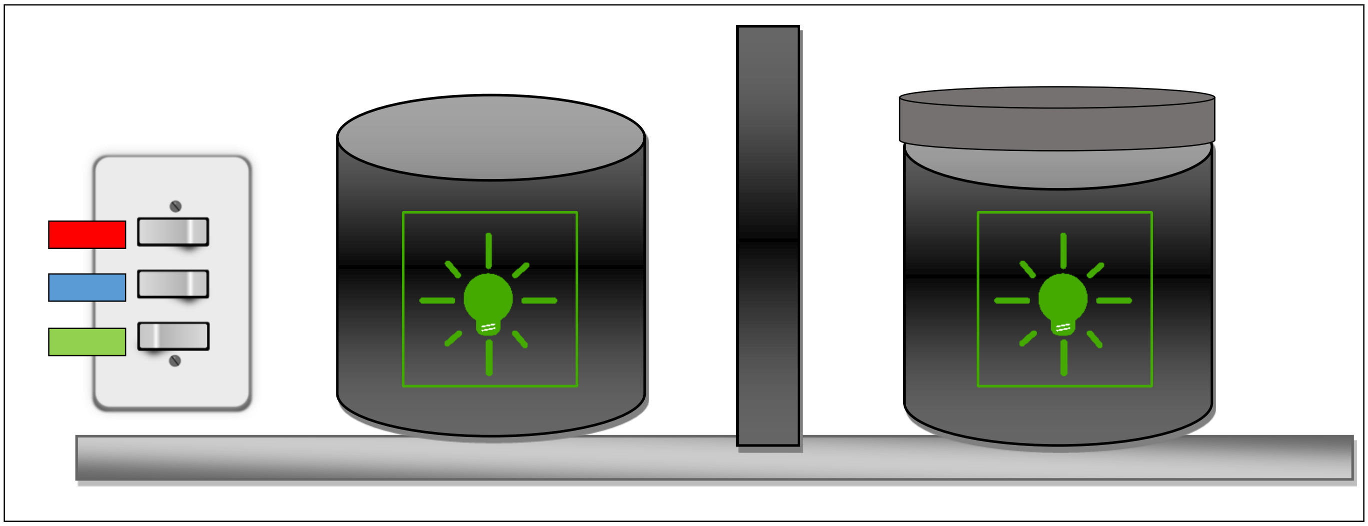

Figure 1-2: Model that depicts the concept of entanglement. By turning on the green light on the left cylinder, the light on the right cylinder also turns green. .

This model illustrates the concept of entanglement when the right cylinder behaves in the same way as the left cylinder. When the green switch is turned on, the left cylinder lights up green. We don't know what color the right cylinder lights up with, because it is covered, made out of the non-transparent material and colored black. One will have to look under the cover to discover what color has the right cylinder lit up with. The same procedure can be repeated for other colors. By completing this experiment, we allow the audience to discover that both cylinders behave exactly the same, although the action of the switching colors was only performed on one. Essentially, this is the concept of entanglement, when two Qubits expose same behavior when they are acted upon in the same way. This allows for prediction of the results and for simultaneous processing.

As explained above The Invitation to Quantum Computing introduces its visitors to the complex concepts of exponential growth and entanglement in a simplified manner. The design was based on the idea of affordance, which is the relationship between an object and the person using the object (Norman, 2013). Both parts of the exhibit will not require special specifies, or instructions explaining how to use them (Norman, 2013), which will add to their ease of use.

Additionally, no substantial funds for creating the exhibit will be required, as both parts of it can be made from the commonly used items, like tables and chairs, LED lights, switches, cylindrical containers. All components required for assembly are relatively inexpensive and should be affordable under Museum’s budget.

Special precautions will have to be followed when the entanglement table is constructed and used, as it involves using electrical power and lighting. No other major concerns are present for safety related reasons. Additional concerns could arise due to the spatial limitations. The first part of the exhibit, consisting of four tables and chairs, may require substantial space, which may not be readily available at the museum.

I hope that the Invitation for Quantum Computing is only educational, applicable and fun, but it is also sustainable, as there are many possible ways to it for it to be extended. From Moore’s Law to Schrodinger's Cat to further exploration of traditional and quantum processors – there are so many great areas related to the content! Additionally, there is one critically important display that would need to be created – on the uses and applications of Quantum Computing, but this goes beyond the scope of this paper.

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