

LEGO Article Translation (Korean → English)

Antony Kim, Class of 2020

Page 1.

TITLE:

The mathematician's (수학자의) hobby (취미는) is to work with **toys** (장난감)

The body of text next to it:

What does a mathematician do in their free time? (Alternatively: what does a mathematician play with?) We may think that they solve math problems in their leisure time based on the mathematicians we see in films and TV series, but there are mathematicians who enjoy collecting toys or [playing] games. As you would expect from experts of math, these mathematicians take toys & study them mathematically, and use mathematical principles to challenge || attempt at breaking world records.

Page 2.

TITLE:

Part 1: A LEGO Mania (덕후) (1) Mathematician's Journey to Break the World Record

Even for 400~500 LEGO bricks, you need to sit down and assemble for 3~4 hours to complete the piece / work (작품) (2). Could you believe that over 3000 bricks were assembled in a matter of 10 minutes?

On January 28th, 2015, at the Williamstown 62 Center for Theatre & Dance in the U.S., 59 Williams College students and 10 Williamstown Elementary School students completed the Super Star Destroyer, one of the LEGO Star Wars line of sets, in 9 minutes and 31 seconds. They had set the world record by dividing the students into 8 groups and assembling 3152 bricks.

Even though a large number of people were involved, it is surprising that a "set (작품)" that usually takes 11 hours to build took less than 10 minutes to assemble. The more interesting fact is that college students took 3 weeks of math classes and strategized to create the LEGO set within 10 minutes.

In early January, 2015, Williams College Prof. of Mathematics Steven Miller opened a 5-week winter study called "The Mathematics of LEGO Bricks(Blocks)." The goal of the lectures was to build the Super Star Destroyer within 10 minutes! For 3 weeks he taught combinatorial analysis, which is used to calculate the number of cases, and mathematical optimization, used to efficiently divide resources, and gave students the [challenge] assignment of coming up with a strategy to assemble the Super Star Destroyer in 10 minutes. Students would then practice assembling LEGO bricks for 2 weeks with their devised strategy.

The text on the bottom right:

LEGO that takes 11 hours to build, completed in 10 minutes!

LEGO Super Star Destroyer

Length: 124.5cm // Weight: 3.5kg // Bricks: 3152 pieces // Instruction Manual: 221 pages // Assembly time: 9 minutes 31 second - the world record // 5 bricks assembled per second // 69 people involved // 59 college students // 10 elementary school students // Preparation period: 5 weeks // Math studying: 3 weeks // Assembly practice: 2 weeks // Important math: Mathematical optimization, Combinatorial analysis

((1) 덕후 here stems from an intentional misspelling / phonetic pronunciation of the Japanese word “otaku” おたく, a term for people with obsessive interests - usually of anime or related Japanese media. Think of its origin to be similar to the internet lingo “n00b,” which stems from an intentional misspelling of “newbie.” When using 덕후 instead of “otaku/오타쿠,” the negative connotation of the word - for the most part - disappears. Hence, it would be completely normal for me to self-describe myself as a “LEGO 덕후” or a “Nintendo 덕후.”)

((2) 작품 literally means “piece [of art]” or “work [of art]”. The word “set 세트” isn’t used as often by the general Korean demographic. As the word is being used here with no other implied meaning, I’ll translate all instances of 작품 to “sets.”)

TITLE:

A taste of / sneak peek at “**The Mathematics of LEGO Bricks**”

What kind of mathematical theory did prof. Miller teach for 3 weeks? It was mostly two theories, [one being] combinatorial analysis, which could calculate the number of “sets” you could build with LEGO bricks, and [the other being] optimization theory, which divided the workload effectively and decreased overall work time.

How many structures can you build with n LEGO bricks? (Top left)

How many unique structures could I build with the LEGO bricks I have? If we take two 4x2 bricks that have 4 cylindrical “bumps” horizontally and 2 vertically, we have $4!/2 + 2 = 24$ ways of assembling them. We could assemble them in the following 46 ways, but 44 of them have the same structure when rotated 180 degrees, so we must divide this number by 2.

[INSERT PICTURE OF 46 4 x 2 COMBINATIONS HERE]

However, if we increase the number of bricks by 1 the number of cases increases to 1060, and if we have 6 bricks it becomes the unbelievably big number of 915,103,765. So, prof. Miller created a computer program that would calculate the number of structures you could build with an x number of $m \times n$ LEGO bricks. The most important point is to exclude any two structures that are identical when rotated. For this purpose, the class also studied mirror transformation / mirror symmetry.

Speed up the calculation speed! (Bottom left)

The problem to calculate the number of cases for LEGO bricks involves calculations so complicated that even computers take a long time solving them. So, prof. Miller introduced an algorithm that helped speed up complicated computations. For example, the Strassen algorithm, which calculates 2 $m \times n$ matrices very fast, and the Karatsuba algorithm, which calculates the product of 2 n-digit numbers accurately and quickly, among others.

[INSERT PICTURE OF LEGO BATCYCLE ON RIGHT]

Getting neat || fine || nice (근사한) solutions (Top right)

Some problems can be expressed as [conditional?] equations. The answer we seek would be the variable x in the equation. However, often times we cannot compute the exact value of x. The quadratic formula, which helps us find the answers to quadratic equations, does not exist for equations of higher degree. So [prof. Miller] taught several methods to find the approximation of the solution to an equation, such as “Newton’s method” and the “bisection method.”

[INSERT PICTURE OF LEGO HOUSE ON RIGHT]

How many teams should we divide ourselves into & assemble? A problem of integer partitions
(Bottom right)

How many teams should the class be divided into to efficiently assemble 3152 bricks? If the class was divided into an n number of teams, how many blocks does each team have to assemble? To solve this problem, we must learn about “integer partitions.” Integer partition is a way of writing any natural number as a sum of 2 positive integers.

For example, 5 can be partitioned in 7 ways: $4+1$, $3+2$, $3+1+1$, $2+2+1$, $2+1+1+1$, $1+1+1+1+1$.

There are 9 different ways to put the numbers 1 to 5 in $3+2$, an integer partition of 5: $\{1, 2, 3\}$, $\{4, 5\}$ / $\{1, 2, 4\}$, $\{3, 5\}$ / $\{1, 2, 5\}$, $\{3, 4\}$ / $\{1, 3, 4\}$, $\{2, 5\}$ / $\{1, 3, 5\}$, $\{2, 4\}$ / $\{1, 4, 5\}$, $\{2, 3\}$ / $\{2, 3, 4\}$, $\{1, 5\}$ / $\{2, 3, 5\}$, $\{1, 4\}$ / $\{3, 4, 5\}$, $\{1, 2\}$. Here, the problem wasn’t that hard since we did an integer partition of a small number, but it gets very hard once the number gets bigger. Hence, we use a diagram called a “Young tableau.” There are a number of mathematical computations we can know about if we use Young tableaux.

The Young Tableau of $3+2$, an integer partition of 5 **[INSERT PICTURE OF YOUNG TABLEAUX]**

The students who took Prof. Miller’s class studied about more mathematical theories and used them appropriately to find an under-10-minute assembly strategy for the Super Star Destroyer. Based on many equations, they concluded that dividing the class into 7 groups would give the most efficient outcome, and so 7 teams assembled 3152 bricks. Wasn’t it 8, you say? The last team was consisted of elementary school students who would tell each team the progress of all the other teams and run multiple errands that needed to be done during assembly. How’s that? Isn’t the power of math - to turn a seemingly impossible task into a manageable one - simply amazing?

LEGO Mania Mathematician

Steven Miller

Q. Why did you attempt to break the world record of building the Super Star Destroyer in 10 minutes?

The purpose of the LEGO class is to use LEGO bricks and teach great math theory and life lessons. I thought it'd be beneficial for the students to learn about organization management through the class as well, so I gave them the challenge of breaking a world record.

When we try to manage things as a group, we are faced with the following problems. How can we efficiently divide - within a group of multiple people - the workload of a task that takes a long time for an individual to do? How can you motivate employees / staff members (직원) with less knowledge about the task [to cooperate]? How do you solve problems when they occur [along the way]?

We ask these same questions when we strategize to assemble the Super Star Destroyer in 10 minutes. As a result, students use "parallelization strategies" - strategies that allow many people to solve a given problem at the same time by dividing complex problems into smaller, manageable ones - and learn about [effective] management.

Through this challenge, we found new, efficient ways to assemble parts of the Super Star Destroyer that usually take too long to build if you follow the instructions.

Q. 10 Elementary school students were involved in breaking the world record. What was the purpose behind their participation?

I wanted to as many people to participate as possible. We gain the strength to work harder if a lot of people are interested in our challenge and participate as well. There are also a lot of interesting things that happen that I cannot foresee ahead of time. In actuality, only 12 college students strategized after taking the lectures, and the rest are volunteers that were only involved in the assembly process. Volunteering at the elementary school was also part of the class, so the college students also taught the younger students math and ways to assemble LEGO bricks.

Q. What was the most memorable moment during your attempt to break the world record?

When the local townsfolk encouraged us, like how you'd expect a crowd to cheer for an athlete, on the day of our challenge. I can't forget the atmosphere of being rooted for by a large number of people.

Q. Did you like LEGO since you were young?

I liked LEGO since I was very young. Since I didn't have that many LEGO sets, I would build the sets as the instructions would tell me to at first, disassemble the set, and then mix them with other LEGO bricks. This way, I could build many "sets" that did not originally exist. In the

process, I slowly became a creative problem solver. I think the appeal of LEGO is the variety of “sets” you could create.

Q. Are you planning on continuing the LEGO class?

I plan on thinking of the class as volunteer work and continuing the lectures. From 2016 and onward, I want to create a bridge with LEGO bricks in celebration of the Selma to Montgomery marches*. Bridges are used to connect to separate places. [So, the bridge we build will contain the meaning of] connecting different races with a bridge made of LEGO bricks. This year’s goal is to create a suspension bridge on the 2nd floor of the school plaza (학교 광장).

The Selma to Montgomery marches*

An African-American voting rights movement led by civil rights activist Martin Luther King Jr.

[INSERT PICTURE OF LEGO SUSPENSION BRIDGE HERE]

The suspension bridge that was built in January 2016 by Williams College students and Williamstown Elementary School students to commemorate the Selma to Montgomery marches. The math problem was to estimate the amount of LEGO bricks needed to build the bridge, design the bridge so it doesn’t collapse, and find ways for multiple people to efficiently build the bridge!

Errors

(All pages)

슈퍼스타 디스트로이어 → 슈퍼 스타 디스트로이어

[Superstar Destroyer → Super Star Destroyer]

Overall, double check if the content written here was what you taught in 2015, if this was what the class did at that time, and if your “answers” on page 4 are direct translations of your actual thoughts.

(p. 2)

Was the goal of the class *specifically* building the Super Star Destroyer within 10 minutes?

(p. 4)

The comment on “thinking of the class as volunteer work”?

To commemorate “Martin Luther King Day,” instead of saying to commemorate “the Selma to Montgomery marches” every time

Clarifying that the Selma to Montgomery marches weren’t the voting rights movement itself, but part of it.