Moving Beyond the Korean System: On Learning To Love Mathematics and Physics

Since elementary school, I have participated in math and science competitions. When I was still a young boy, a 4^{th} grader, I solved math problems at school until 6 o'clock. My teacher wouldn't let me go home earlier, and, as a result, I was always successful in the competitions. This schedule didn't change much when I entered middle school and high school. I practiced solving problems for physics competitions and eventually won many prizes. Later, I participated in the International Physics Olympiad as one of five students for the Korean team, and won a silver medal. Yet, during seven years of preparing for numerous competitions, I have hardly spent any time mulling over the true value of my success. Nor have I thought about whether I truly liked solving all kinds of math and physics problems. In middle school, I diligently prepared for science competitions, because that would make it easier to get into a science high school. In high school, I solved physics problems to get into competitive Korean colleges and later into American colleges. However, in Italy, where the International Physics Olympiad was held, I realized the true value of studying physics. After the examinations, we, five Korean students, played a card game all day, while five students from the U.S team talked about quantum mechanics. First, I wondered why they had studied quantum mechanics that would never be on the examination. Also, I could not understand why they studied physics after the examination. Apparently, one of them, who had a comprehensive knowledge of quantum mechanics and had done some research using it, had received a lower score than Korean students who had only a rudimentary knowledge of quantum mechanics.

Clearly, there was a great difference in the motivation of the Korean students and the American students to study physics. The Korean students studied physics to get into colleges, while the American students studied Physics because they liked it. The Korean students didn’t have much time to think about whether they truly liked physics. Even if they did like it, they didn't have much time to study materials that went beyond the physics competition.

Since then, I've come to Harvard to continue studying physics. There was no other major I wanted to consider, as physics is a subject that I can deal with competently and physics truly interests me. However, after studying here for three months, I find that physics and math are not merely interesting, but exciting. Now, I truly understand the American students who studied physics even after the examinations. Science in Korea is taught in such a "wrong" atmosphere that many students, who could otherwise have been passionate scientists, lose interest in science. Nonetheless, as I am not a working scientist of any kind, I am not in the position of advising students how to study math and physics. Yet, based on my personal experience so far, I will talk about my idea for how students should study math and physics, and how they can be taught well. Also, I will talk about why I find them interesting.

In his essay “The Achievement of Desire,” Richard Rodriguez tells his story of being a “scholarship boy.” “Scholarship boy” is a term coined by an educational theorist to describe overachieving students who move between their home and schools, which are “at cultural extremes” (46). While a scholarship boy misses home, he studies hard to forget his longing and begins to value the benefits he receives from education, such as discipline and logical reasoning. He begins to see “life as a ladder, as a permanent examination with some praise and some further exhortation at each stage” (67). However, according to Rodriguez, a scholarship boy is a bad student. While he “over-stresses the importance of examinations,” he is only a great imitator who doesn't have his own opinion (67). Nevertheless, Richard Rodriguez states that he himself achieved the “end of education” by acquiring the ability to describe his own ideas, even though he received an “inevitable miseducation” as an imitator, or a “scholarship boy.” He argues that this miseducation, which largely consists of imitating and learning other people's opinions, was eventually helpful and necessary to formulate his own ideas.

Korean students may be seen as scholarship boys. Most of them see life as a ladder with permanent examinations. Yet, there is a fundamental difference between scholarship boys and Korean students: Korean students are not exposed to different atmospheres at home and in school. At home, parents always encourage studying hard, and at school, students study extremely hard. For twelve years of pre-college education, every Korean student is in a big competition for acceptance letters from colleges. Korean students constantly try to find out the rank of competing students; if there is somebody out there with a much higher rank, a Korean student tries to catch him, to be better than he is. Parents teach their children that life is a ladder with examinations that lead to the admission into a prestigious college, and the children agree with this view. Korean students believe that if they don’t accept this idea and if they don’t study hard, they are bad students.

Therefore, Korean students are worse than scholarship boys. While scholarship boys have a valuable goal, to become an educated person, Korean students have a somewhat meaningless goal, "the college." Once this goal is achieved, many Korean students are burned out. If their goal is not achieved, some of them try again to get into prestigious colleges. While Richard Rodriguez's goal was to obtain the ability to think abstractly and express his own opinion, a Korean student seriously misunderstands the goal of education. After a Korean student enters college, he no longer finds any reason to study hard. Moreover, a Korean student doesn't usually think about whether he truly loves studying and learning, as he regards studying only as a competitive tool. Nor does he have enough time to delve into the subjects he loves; he has to memorize facts to get a high score on the Korean SAT.

In this atmosphere, education, including science and math education, emphasizes solving multiple-choice questions. Students learn tricks and solve a lot of problems. It was lucky for me to find my interest and my ability in this Korean education system. When I was in elementary school, I had a lot of free time, and I read many math and science books that I found interesting. As time passed, I had to study hard for math and science competitions. I solved an enormous amount of problems. The preparation was moderately interesting, even though by the end I was a little bored and the pressure for the examination was high. It was lucky for me that the Korean government changed the education policy, so that winning a prize in a math or science competition increases one's chances of getting into college. Nevertheless, some students didn't get good prizes in the competitions and couldn't do well on the Korean SAT, because they spent too much time solving math and science problems.

After all these pressures and competition, I graduated from high school and took a rest for half a year before I came to Harvard. Here at Harvard, I study, not to get into a good college, since I've already gotten into one, but to fulfill my dream of becoming a scientist, so that I can broaden the knowledge of mankind in the near future. I study not because I am pressured to, as was the case in high school and middle school, but because I now find mathematics and physics interesting and exciting. During 7 years of examination preparation, I didn’t have much free time to study on my own, but here at Harvard, I have the freedom to do whatever I want. Now I truly find that math and physics are subjects that I love to study and want to work with during my free time, rather than solving an enormous amount of problems.

Physics is something that I have studied a lot before, so I didn't learn many new things during my first semester at college. On the other hand, I've developed a new appreciation for mathematics, as I've learned new concepts. Before I came to college, I had the wrong impression of what college mathematics would be like. I had studied some Calculus, Multivariable Calculus, and Differential Equations, and I thought college mathematics would not be that much different; I thought college mathematics would probably consist of learning new methods of solving complicated Differential Equations more easily, among other things.

However, this was not the case. As I was introduced to new concepts, new fields of mathematics, a whole new world opened up for me. Some concepts were hard to grasp, but I acquired them by solving problem sets. When I finally understood the concepts after finishing up the problems, I felt excited. The confusion that I had about specific mathematical topics disappeared, and I came to realize clearly which parts I understood correctly and which parts I did not understand. For the parts that I still do not understand, I can try to do some calculations on my own or I can refer to other mathematics books. One of my physics professors once explained to me that an understanding of a new concept doesn't occur gradually, but rather as a radical jump from an old concept to a new concept. Apparently, this jump is the reason I enjoy math and physics. Another professor once advised me to solve some problems to check whether I correctly understand a new concept.

However, I have seen some other students who have the wrong idea of how to study math and science. They do not try to nail down new concepts, and they just believe what professors said in lecture, because a professor's calculation and explanation must be correct. They think that mathematics and physics are very logical, so they can catch up later. Then they try to solve the homework and complain that it is difficult. They may think that to solve a mathematics problem, one needs to have a lucky idea. This may be true. Nevertheless, one can easily find such tricks and a natural way of solving problems if one understands what is happening in the problems in terms of the new concepts, of which one is totally convinced, not just one blindly accepts. Fields medalist, Sir Atiyah said, "The idea that mathematics is synonymous with logic is a great ridiculous statement that some people make" (String). Also, Jerome Bruner argues in his essay "On Learning Mathematics" that

> It is important to allow the child to use his natural and intuitive ways of thinking, indeed to encourage him to do so, and to honor him when he does well. I cannot believe

> that he has to be taught this [very rigorous way of learning mathematics]. Instead, we should first end our habit of inhibiting intuitive thinking and then find ways of helping the child improve at it. (105)

Bruner’s argument does not only apply to children, but to high school students and to college students as well. When one studies mathematics and physics, one should remember to use visualization and imagination as much as possible. This is precisely the reason I like some of the well-written mathematics books for physics students, as they implement intuitive ideas and thinking rather than a rigorous way of proving things. Similarly, I understand better when I listen to a professor's lecture than when I read a poorly written mathematics book. Some mathematics books do not deal with visualization and imagination at all, while professors always draw pictures on the blackboard. Clearly, intuitive ideas and imagination have helped me enormously with math and physics.

There may be two reasons I am successful in mathematics and physics, other than my use of intuitive ideas and imagination. First of all, I am excellent at calculations, as I have solved tons of problems. These exercises enable me to make fewer mistakes in actual competitions or examinations. However, I do not believe that excellence in calculation is a necessary skill for a mathematician or physicist. In actual scenarios, mathematicians or physicists always have enough time to calculate and need not hurry as if they are taking examinations. Another and more important factor for why I am successful in mathematics and physics is that I have been provided with many examples for each new concept. In his essay “On Learning Mathematics,” Bruner talks about a ten-year old playing with snail shells. Bruner explains that the boy will later grasp the meaning of prime numbers easily, as he finds out that there are certain quantities that cannot be arranged into rectangular arrays (103). The same rule might have applied to me. Solving a lot of math and physics problems might have served as a good background for new concepts in mathematics. Moreover, I enjoyed "playing with mathematics," like the ten-year old playing with snail shells. Whenever I learned a new concept, I tried to make some examples and play with them, to make sure that the new concept was convincing. Especially, when I had an enough free time during elementary school and my half a year break between high school and college, I occasionally tried to extend the concepts I learned. After I learned how to solve quadratic equations, I tried to solve cubic equations. I "got" the answer, only to find that my answer was wrong, as I had implemented a dumb way of approaching the problems. Later on, I went to a library to find out how to solve cubic equations. Then I realized the fundamental difference between my way of approaching the problem and the "lucky" way of approaching the problem that led to the right answer, which was discovered a few centuries ago. Even though I couldn't get the solution, I learned why my way of approaching the problem was dumb, and why it couldn't have led to the solution. During my break between high school and college, I tried to solve the volume and surface area of an n-dimensional sphere, as I had already known the volume and surface area of a 3-dimensional sphere. Later, I compared my answer with the right answer in a book and found out that my answer was right, even though my way of approaching the problem was somewhat different. I think that this kind of exercises gives me some rough idea of what kind of methods will not lead to the solution in mathematics problems, even though they do not always tell me what kind of methods will definitely lead to the solution.

The Korean system of math and science education is very helpful in that it helps students with calculation skill and provides them with a lot of examples by making them familiar with a huge amount of problems. However, it has its disadvantages in that it is also likely to bore students with science and to imbue them with false images of science. Also, it prevents students from playing with "mathematics" on their own, by taking away their free time. Therefore, I believe, in math and science education, homework should not be lengthy, but should be enough to help students grasp new concepts. For example, the problem sets for the math course “Honors Multivariable Calculus and Linear Algebra” that I took this semester were excellent, not only because it gave me an opportunity to check whether I understood new concepts that I had learned in the lectures correctly, but also because it was well designed to discover by myself new concepts that had not been mentioned in the lectures.

Students studying math and physics should be constantly aware that math and physics are all about imagination tied up with logic. When you are introduced to a new concept, try to understand what it means by looking at examples in the book and drawing pictures. Then ask numerous questions regarding the new concept that can clarify your understanding. “How should I accept this new concept in terms of the concepts I already know?”, “Could this situation be applied to this new concept?”, and so on. Sometimes, even though you know that you do not understand a new concept quite well, you may find it hard to make an appropriate question, of which the answer can help you understand the new concept better. After making up numerous questions, try to figure out the answers to them. If you can’t figure them out and find the new concept somewhat contradictory or confusing, ask somebody else. If you can figure them out, form your own image of the new concept. Then solve problems. If you can’t solve them, try third to get the solutions. You will feel the euphoria of achievement. If you can’t, study the concept again or ask somebody. Once you get the answer, carefully see if it fits into your own image of the new concept. If it doesn't fit, try to find where you have gone wrong with your own image. If you find the problem, fix it. Then, as you study, you will be introduced to more concepts later on, and you will repeat the similar procedure. Sometimes, you might even need to figure out the questions for yourself. And then you will learn to love mathematics and physics.

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