What Knowledge is of Most Worth?

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A Bathroom Encounter

It was *him*. Oh my God! I knew my high school English teacher was behind me when I entered in the school bathroom. Thinking of how to acknowledge him made me nervous, as I was not doing particularly well in his class. I wondered if I should I say something first. Before I had a chance to decide, Mr. Dawei addressed me.

"Yang Zheng, I know, you are troubled. *You need to work for it.* English is very important, you know, not only to get a good score on the Gaokao, but also to get into a good college. You'll need to have CET 4, then CET 6..."

I understood every word he said. I knew he was going to say something about my poor English, yet I could not think of a single word in response. His words rendered me speechless. The sadness and hopelessness that I felt soon turned to anger. "Damn him and the Gaokao! Damn all of this!" With so many emotions swirling in my head, I didn't know how I felt. After Mr. Dawei left, I washed my hands in the bathroom sink, replaying his words in my head, unable to erase his voice from my thoughts. I stood in front of the mirror for a long time, splashing water in my face while trying to shake off his words. I wished there were a magic potion to make my English as good as his, but I understood there were no quick fixes when it comes to learning a language, so I probably shouldn't worry about it anymore.

The Best Mathematics Student

I had just shared a solution to an impossible problem in math class. My classmates were amazed by the elegance of my approach. Several expressed disbelief. "How in the world did Yang Zheng come up with that argument?"

"Yang Zheng is not a magician! He's just a very talented young man. More importantly, notice how hard he works in this class. I don't give him anything. Everything Yang has accomplished has been earned through diligence, tenacity, and intellect! Students, I call on all of you to learn from Yang Zheng! Be like Yang Zheng in all that you do, and you will go far!"

I was so moved by my math teacher's compliments that tears welled up in my eyes. I was proud and happy to know that Mrs. Yanhong recognized all of the effort I had been putting into learning mathematics, and I knew I could do *even better* if I practiced more. With the encouragement of Mrs. Yanhong, I began to play a more active role in class. For instance, when my classmates were stumped on difficult problems, Mrs. Yanhong and I would work together to help students. I became increasingly interested in mathematical proof during this time. Whenever my classmates could solve a problem using deductive reasoning (rather than through measurement or trial and error), I would encourage them to do so.

As the year progressed, I assumed the role of teacher more frequently, leading the whole class in recitations of theorems that I used many times to figure out proofs. On numerous occasions, I was able to complete arguments that stumped Mrs. Yanhong. My classmates began to look to me as their teacher. For instance, the most popular student in my classes started asking me for help. While he was better than me at so many things, I took pride in knowing that I could compete with him for the title of best mathematics student!

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Preparing for the Gaokao

My Future, My Reputation, My Family

In less than a year, I was going to take the most difficult high school exit exam in the entire universe, the dreaded Gaokao. The exam is like a final battle—all of my previous years of study and efforts were in preparation for this battery of eight-hour tests. I could not believe the time had come. I didn't want to face it. Over the years, my older friends and family shared their thoughts and memories of the test. Their descriptions of the Gaokao induced anxiety in me throughout my time in high school; they undermined my self-confidence. I wasn't not sure if I'd be able to answer enough questions correctly on the Gaokao to earn a place in a good university.

> *If I don't get into a good college, I won't be able to get a good job or earn enough money to take care of my wife and children. Without a good job and family, how am I supposed to be a successful adult? Oh. My. God!!!*

The more I thought about it, the more my stomach turned. It became increasingly apparent that my entire future hinged on the Gaokao. My father once told me he would quit smoking (once for all!) if I were accepted to Xi'an Jiaotong University—a prestigious school near my home. My father worked there. If I didn't get in, I knew my father would lose his face in front of his co-workers and friends. They would know *exactly* what happened—that Yang Zheng failed the test. They would ask him about it, and the questions would devastate him. So, the pressure of the Gaokao wasn't limited to the test-taker, but extended to the entire family. *The pressure was truly intense.*

The Sciences + Chinese + Mathematics + English = Content Concerns

I wished that I had more time to prepare and had more teachers who were better equipped to help me learn. I would have stayed in the lab longer doing science experiments. Maybe I would have taken more interest in building my English speaking and writing skills, too. I wished that my teachers and classmates were more patient in helping me. Unfortunately, there wasn't time to help slower students.

Physics and chemistry were going to be challenging. I had three high school chemistry teachers in less than three semesters: the first teacher was very good. He engaged us in inorganic chemistry using teaching methods similar to those that I encountered in middle school, so it made sense to me; the second teacher was not bad, but her explanations of diagrams in organic chemistry were baffling. And she spoke *so fast*. I never figured out her diagrams; they were so bad, I just gave up on them.

In addition to the sciences, I was concerned about my ability to do well in the three "core" Gaokao subjects: Chinese, mathematics, and English. I didn't see why I had to take the English exam. Too many tough words, too many long sentences, even longer paragraphs, and MUCH longer articles to interpret. And don't get me started on verb tenses and grammar: *past future tense, past finishing tense?* These don't exist in Chinese. To be honest, to this day, I've found few similarities between Chinese and English. "*Why is English is so difficult for me? Is it true that Chinese people can't learn English? Would it have been easier to learn if my native language was German or Spanish rather than Chinese?"* I wished my Chinese teacher and English teacher could come to the class at same time and teach us the two languages together so I could understand them better. *Why not?*

For me, the most intimidating aspect of the English test was the wide assortment of readings on the exam, each accompanied by a litany of multiple-choice questions.

None of the articles would be familiar. Nobody would have read them prior to taking the Gaokao.

English is a Dark and Dangerous Forest

The English exam was a dark and dangerous forest, and I found myself all alone in the middle of it without any equipment—no map and no GPS to guide me. Each word was an adversary—cold, unfamiliar, and dangerous. And when words stood together to form sentences, I was in mortal danger. For the most part, I was unable to make sense of sentences—much less paragraphs, passages, and articles.

The multiple-choice questions that followed the readings were like arrows coming from nowhere in rapid succession, slung to penetrate my heart, to kill my chances of having a happy, successful life. I felt hopeless, looking through the list of the subjects. I had wasted my time doing challenging mathematics problems when I should have put more effort into learning English.

> *Who is to blame? Am I the problem? Perhaps I didn't use the right methods to learn? I'm beginning to think there's more to it than that. I'm starting to wonder if there is something inherently wrong about the Gaokao itself. Or maybe the entire system of education? Is it right to focus so much energy on a single high-stakes test? If a student wants to study mathematics (or any other content) after high school, why not let them? Do I dare raise such questions?*

In the quiet of my room, I began to think the unimaginable. What if I skipped the Gaokao and instead focused on what I want to do as an adult? I really wanted to be a teacher, focusing on either mathematics or Chinese. I was leaning towards mathematics, since I was so good at it in school and because helping others brought so much joy to me. I liked the feeling of sharing my mathematical insights with classmates like I did back in Mrs. Yanhong's class. I had not found the same joy in other subjects, like physics or political science. However, my dreams of becoming a teacher were tempered by the realization that my poor performance on the Gaokao would matter.

> *How can I even be qualified as a teacher when I am such a poor student in so many subjects? Maybe I can teach my students by sharing my failures with them. Is that even possible? Has anyone teacher taught things that way? Not that I know of, and certainly not the teachers I've had so far. They say you learn more from your defeats than from your successes. If that is true, maybe I have something new to offer my students—namely a new perspective about student assessment, achieving one's goals, and the nature of teaching and learning.*

(Note: When I took the Gaokao in 2003, it was possible to get an exemption from taking the test. For instance, if a student won a medal from an academic competition, they could petition to skip the test in that subject. However, due to my personality and lack of information around that time, I was never trained or thought to be trained or engaged in the activities of math Olympics. So, I had to take the Gaokao.)

Learning English from Many

"There is an exchange program between your school and a school similar to yours in the United States. You think you want to go? I can ask your uncle about it."

"Yes, I want to go. I just want to be better at English, and I want to study mathematics.

I'm curious to know how the Americans learn math."

"Yang, you can do that! Your uncle can help you!"

"The only classmates I've ever had have been Chinese. I'm so eager to explore new places and new people—a bigger world!"

Within a few months, I received notification of my acceptance into the program, and I was able to get a visa to the United States (without question, this was an incredible stroke of good fortune). I arrived the airport in Topeka, Kansas, at 2 am, with a group other bleary-eyed Chinese students from the same school. I still remember the date, August 17, 2005. From far-away, I could see a group of Americans waving hands at us. They were all smiling. Later, I learned that some of them were professors from my new school, Emporia State University. Others were future friends from the local church. *I was very excited, and I couldn't explain exactly why.* In fact, I still don't know how I was able to speak English that time, or why I was so desperate to speak, since my English was truly poor. I got into a van in the back seat with an African-American student,

"Hey, Asian dude! What's your name? Where are you from?"

"My name Yang Zheng. I from Xi'an."

I was getting more and more excited as I talked, I didn't care about my grammar mistakes because he was such a good listener and talker too! I could not stop talking even though I spoke with disconnected words and made extensive use of hand gestures to help describe. I don't recall how long it took for us to get from the airport to the school dorm, but I was not sleepy when I finally reached my destination. During the ride, I probably used much more English than all my past years at school in China. I was so happy that I could speak English in the moment and people could understand me. I was in the United States, a country where people speak English, and I was going to be successful. I could feel it!

After I arrived at the dorm, I settled down and talked with Chinese friends who also came along for this trip. It was about 4 am. The assistant (who was also Chinese and working at international office) who in charge of our program came to tell us that ther ewas an English test that I had to take in the morning at 8 a.m. in order to be placed in at the appropriate level for English lessons. Only those who had high TOFEL scores or who decided to major in English were spared! "My God!" I thought, "*Will I ever escape English tests?"*

I ended up getting placed to the lowest level of English speakers. As such, I would need to complete ALL of the English lessons that the staff had created: speaking and understanding (intermediate level), grammar (advanced level), and reading and writing (intermediate level). Even now, nearly 20 years after the fact, I can recall how motivated I was to learn all those lessons. I made strong friendships with all my English teachers (all Americans) and more happily, I befriended many students, all English Language Learners from many other places in the world, including Japan, South Korea, and Middle East countries. I found that learning language with my classmates was a natural and joyful activity. English is the common language we spoke. Occasionally, we shared our native languages and cultures with each other. At the end of year, I finished all of my assigned English lessons with high marks. I even won the first award in my life, for the best performance in reading. I was starting to understand English better. As famous mathematician Heisuke Hironaka is reputed to have said, "I believe that the best learning outcome is something we WANT to learn, not what we NEED to learn." I couldn't agree more. In fact, I did not just learn English from attending class. I also learned by watching movies in the dorm with other students. Moreover, I purposely struck up conversations

with strangers in the cafeteria to improve my speaking, and I spoke English with my Chinese friends. All of these steps helped me to improve my English-speaking fluency. Once my learning attitudes changed and once I believed in myself as an English speaker, I learned much better and more quickly.

Year 2050: An Imagined Future

"Professor, this problem is impossible, so I asked TXGM."

"TXGM? Transformer X Great Mind? I don't know how I feel about that."

"You're not sure if you like it? Professor! TXGM is awesome. Look, it already generated a solution!"

"Okay, that's fine. But you see…"

Before I have a chance to explain how I would attack the problem the "old-fashioned" way (i.e., using my own knowledge without assistance from a machine), the student has already run out of the room for another class. I don't blame him. This is very typical behavior in my classroom. The content that I teach—calculus, linear algebra, differential equations, probability, statistics—are trivialized by TXGM. The machine solves math problems better than my best students or my strongest teaching colleagues. *The machines are the solutions*. For a "teacher" like me, I mostly teach the theory that underlies the problems my students study. If I'm being honest, the best part of teaching is teaching students about history behind the mathematics we study—the personalities and political contexts that gave rise to the mathematics that we take for granted today. Since students can solve calculations with TXGM, I have more time to share humanistic aspects of mathematics with my students. I also love sharing my life with my students—personal stories, my research work, and anecdotes about teaching and learning. Unfortunately, TXGGM (i.e., Transformer X Great, Great Mind) can do ALL of these things better than me or my colleagues. Moreover, it is common for students to take 100 credit hours or more of coursework each semester. Thirty years ago, this would have seemed ridiculous. Back in the 2020's students weren't allowed to complete more than 20 hours a semester (even that was too much!). In addition, much of the mathematics I learned in college is now taught in the middle grades or high school.

"So TGM1 (i.e., Transformer Genius Mind 1st generation), can you offer me some hints for proving this theorem?"

"Theorem? This?"

"I know. I know. I'm still not totally sure if we can call this a theorem. I just made the conjecture, but I believe it's true. Please, just some hints, not the final decision, because I want to think for myself a little bit more…"

"OK, I cannot prove it either. But I can show you more evidence for why this might be plausible."

"That would be useful. Go ahead."

This is what I usually end up doing, again, talking to the machine to ask for help. EVERYONE does it. Me. My teaching colleagues. All the undergraduates. Just like my student, I cannot prove the conjecture, so I resort to using the machine. Honestly. I don't feel like thinking for myself anymore. Research collaboration between two humans is now exceedingly rare. Research papers are often written by human and machines together. Of course, machines like TGM1 have published countless papers with humans. In other sciences, like biology, chemistry, or physics, many papers are written completely by machines. Thanks to the AI technology popularized many years ago, I have published more papers with machines than with my human colleagues.

After the day of "teaching" and "research," I choose to walk back home, since I'm tired of using TGE (Transformer Great Energy) to take me home in just 5 seconds. I also don't feel like I have accomplished much during the day (Maybe I have already completed a math research paper, but that seems too easy and little boring). I hope to see some real people like me on the way home.

An old man comes up to me, "I'm so sorry, I forgot to bring my TGM (Transformer Great Map) with me. I'm lost. Can you help me."

I look at the name of the station and I immediately realize this is one of the stations I passed by earlier today. I didn't recall exactly where it was, but I knew the route I had taken.

"I can just walk with you and show you where it is."

I don't know why, but I have never been so excited, even though I also don't have the answer for him. For a long time, I have not engaged in this kind of simple conversation with a real person. It's been a long time since I was able to help someone without the assistance of machines. It feels good to walk. I want to make mistakes, and I want to talk with this man on my way home.

Wait, isn't he my high school English teacher? I have to ask him!—because maybe he's just another machine human. Who knows?!

Back to Reality

During a break of the International Conference of Education (The theme of the year is on implications of the new world with super-intelligent machines), I was interviewed by a student:

Q: How has your role changed?

A: I have always seen myself as a student, rather than a teacher, even though I have been in the job for more than 10 years now. From kindergarten (about 4 years old) until finishing a PhD at university as a 30-year-old, my role was that of student. My job was to learn from many teachers, other students, from my parents, and many other friends—all real people. We rarely learned directly from machines, except sometimes using computers to help do some standard work or simple mathematical computations. After I became a university teacher, I realized that my students' backgrounds were not like my own. Their daily world is saturated with technology and intelligent machines. I find it necessary to learn from the "new" world and the evolving technology, so I can better understand what I teach and who I teach. So, this is why I think I am also a student.

Q: What are advantages and disadvantages of this "new" world?

A: This is such a big question for all of us to think about. Our knowledge is updated. Technology helps us solve problems that we
thought were too difficult or impossible. Artificial Intelligence (AI) has helped mathematicians proving countless conjectures, something I find very exciting. Since we've invented an intelligent machine to solve Gaokao problems, students in China can focus more time exploring topics that matter—global warming, overpopulation, poverty. Although this is a blessing without question, AI also brings potential disadvantages. For example, now that smart machines do everything for us, how do we help our students remain motivated? For so long, the Gaokao was THE reason students worked hard in

China. Now students need to find other sources of motivation. This transition to a post-Gaokao world is not an easy one for teachers, students, or curriculum developers.

Q: This situation is worrisome. Can you say some more about how the machines impact the Gaokao?

A: This is a difficult question for me to answer. There are both potential advantages and disadvantages to the Gaokao itself. The answer depends on the individual. One advantage is that we use the test to help us select the students who can continue to do well academically. Of course, we also know this cannot be a fair test for ALL students. Now with the developing AI technology (and more advanced technology in future), we have many problems to face. For instance, we need to fully understand the AI so we can use it wisely. The other is that we need to rethink what we should teach to our students given the powerful technology. There are certainly lots of decisions to make. Recall that some people have access to AI and others don't. For those who don't have it, this presents the equity issue for education.

Q: Will these challenges continue to exist for students in future? Overall, do intelligent machines provide more benefits or more
problems?

A: I actually do not have an affirmative answer to your last question. I hope the machines can provide humans more benefits. And we will have to face new challenges in future. Based on my own learning experience, I would certainly prefer to have my experiences rather than the precise answers that are offered by the machines. To really learn, it is necessary for humans to struggle, to think, and to understand with our internal minds. For example, machines have started to help us better understand principles of physics, chemistry, and mathematics. I honestly think that machines should help us to learn better, like the VR technology, to help young students to do experiments that I could not when I was in school, so they may better understand the theory and discover new things. I expect machines will truly help students in learning mathematics by letting students focus on the core ideas and concepts connected to other fields, so they can understand and discover the interest in mathematics for themselves, without doing repeated practices which may not entirely be necessary (like many of those I was doing in middle school). Certainly, the machines can help us translate one language to another. So English isn't really hard for Chinese to learn (the way it was for me).