CHAPTER 8

Team Players to Shape our Future: Do our Students Learn the Right Skills?

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Education is the key for success and welfare of a country. Figure 1 shows the correlation between the wealth intensity and the number of citations in scientific journals. Switzerland is among the top nations. It has a special, so-called dual education system (Figure 2). From age 16 onwards, the majority of our young people receive practical training in a company, and a minority of only about 20% (Figure 3) attend senior high school, which provides the entry ticket to one of our universities. This system is different from many other countries, but it is an effective tradition and generates the lowest unemployment rate among young people in Europe.

DEMANDING BASIC EDUCATION

ETH Zurich is a 154-year-old technical university with degree programs in architecture, engineering and science. At the beginning of their studies, the students have to go through a demanding basic education — mathematics, physics and chemistry — before concentrating on their field of choice. Among the faculty members and the students there is a large number of foreign people. This is done intentionally as a small country has to recruit from an international pool of talent. It also gives our students exposure to different cultures and, last but not least, it generates an element of competition. But the question remains: do our students learn the right skills?

The global community today is confronted with complex, long-term tasks that are the core business of universities. To meet these Great Challenges,

such as climate change, energy conservation, clean mobility, ageing population and sustainable food production, we need excellent interdisciplinary research and highly skilled scientists and engineers. In the world of science, national borders do not exist; researchers work in international groups in order to achieve the best results.

THE ARCHITECTS — PLANNERS OF SUSTAINABLE CITIES

One Great Challenge for architects is the sustainable planning of future cities — cities with a population larger than the size of Switzerland — which means more than approximately seven million. Architects not only have to design houses and streets, but also have to involve the dynamics — which means they have to understand the interplay of the flows of people (mobility), of energy, water, and the flow of waste. It needs the skills of an artist, the know-how of a designer and knowledge of the physics of energy in order to achieve optimal solutions for different climate zones. Architects should also understand the social behaviour of different cultures.

It is thus clear that modern education needs the exchange of global knowledge and knowledge of different cultures. The best way to achieve this exchange is through the mobility of people — of people who are eager to learn and who want to shape our future.

THE ENGINEERS — DEVELOPERS OF HIGH-TECH SYSTEMS

Engineers have built the modern world around us. Mobile phones, computers, cars, planes, power plants and many other technical products are proof of this. For example, we had a period in Switzerland about 100 years ago when all the trains, tunnels and dams in the Alps were constructed by engineers educated at ETH Zurich.

Today, engineers design high-tech systems, but sometimes, although these products are top class, they are too expensive for developing countries. An example of this is the hybrid car with a conventional engine and an electric motor in addition. The team responsible for this at ETH Zurich — Professor of Mechanical Engineering Lino Guzzella, together with his students — designed an intermediate energy storage with compressed air, driven by a conventional engine filled during breaking. In the successive acceleration of the car this stored energy is recuperated, and therefore it is possible to save 20 to 30% of gasoline.

THE SCIENTISTS — TEAM PLAYERS FOR FUTURE SOLUTIONS

Due to the worldwide ageing population and the corresponding development of medical technology, collaboration between engineers and medical doctors

is becoming more and more important. ETH is very active in this field and plans to enlarge its activities even further. Also quantum science has a long tradition at ETH. And the great masters and Nobel laureates Albert Einstein, Erwin Schroedinger and Wolfgang Pauli spent part of their scientific career in Zurich. But what comes next? The quantum computer, quantum cryptography or the single electron transistor in commercial products? Involved are physicists, electrical engineers and computer scientists — they are the team players for future solutions.

SCIENCE — AN ADVENTURE FOR YOUNG PEOPLE

Where are the adventures for young people today? The North Pole has already been discovered, men have been to the Moon. But I am convinced that science can still fascinate young people. It offers really true adventures of a different kind — to discover unknown territory through hard work. We are curious to understand the big bang, the beginning of our universe. We are looking for answers to questions such as what dark energy and dark matter are made of. And, although we know the structure of proteins, we do not know the dynamics of life. Or, for example, what do the 10^9 proteins do in a cell? We still are not able to design a computer with the power of our brain and an energy consumption of less than 50 Watt. Real life problems are the most difficult to understand because they need input from many different disciplines.

The question remains: how to attract the best talents in this worldwide contest? ETH Zurich assigns to its students tasks that are a mixture of adventure and competition. Adventure is a driver for discoveries, and competition a motivator for top-quality performance — and an attraction for creative young people in scientific technologies. Research projects like a soccer game for micro-robots on a mm^2 playing field, or a self-directed sailing boat to cross the Atlantic Ocean — such projects and many others inspire the pioneering spirit and evoke visionary dreams.

MODERN EINSTEINS ARE NEEDED — FOR INTERDISCIPLINARY AND INTERNATIONAL TEAMS

We need a lot of Einsteins to face these challenges — but modern Einsteins! He was a genius and discovered new physical theories, and without them no particle accelerator would run today. But he also was an individualistic scientist working alone in his study. In fact, he was not a big team player. Today however, we need to train scientists and engineers who can work together and who are able to cross the boundaries of their original disciplines. Modern Einsteins must not only have a high-class, scientific education, but also social

competence — for instance, they have to be able to communicate with people of different disciplines and cultures.

Interdisciplinary projects demand enlarged skills that can only be acquired in several stages. We have learnt over the years how to judge the quality of projects in specific disciplines, and we know how to make a career in a specific discipline — that is tradition and business as usual. Therefore, it is my strong belief that it is mandatory to first become a champion in one discipline. But the second part of an academic education has to deal with students having to learn to talk to people from neighbouring disciplines. For example, a physicist should be able to understand a biologist and vice versa. Or a civil engineer should know the scientific problems of a chemist. More than mere curiosity should drive scientists to find a solution for a scientific problem. They should also dedicate themselves to finding solutions to one of the world's Great Challenges. We need both of them!

PROJECT LEADERS LEARNING FROM PRACTICAL EXPERIENCE

I have described the example of the architects in the field of city planning, now I give you another example: most IT projects fail, not because of technology, but because of the lack of understanding of the customer's needs (but also the customer does not always know his or her needs). In addition, software projects often involve people who are located in geographically different places. Therefore, we also need good project leaders, who monitor the different tasks, the time schedule and the budget as well. Is this something you can learn in a theoretical lecture? Not really; because one also has to practise it. ETH students have founded a company called "ETH Juniors". The management consists of eight people who acquire jobs from the industry for students. One out of ten inquiries to the industry was successful. And this is an example for a training in patience and endurance. Last year, they had a turnover of a million Swiss francs.

ETH Zurich provides the basics and support to all these "soft skills". Every student has to select from a broad line-up of topics from our department of Management, Technology and Economics and from the department of Humanities, Social and Political Sciences. There are lectures about management abilities, the history of science, Asian history and culture, or behaviour sciences, just to name a few.

BUILDING A BETTER WORLD — RELYING ON SCIENCE AND TECHNOLOGY

Besides becoming a champion in his or her academic field, the student should obtain a broader view of our planet. As I said, we need modern Einsteins — with innovative scientific ideas and social skills. My hope goes in the direc-

tion that globalization will preserve some of the cultural differences between nations. By respecting each other, we will build a better world. For this ambitious plan we have to rely on science and technology.

THE ROLE OF HUMANITIES AND SOCIAL SCIENCES

So far, I have emphasized science and technology. Physics is a way of thinking. Each complex problem is cut into sub-problems, which can be solved. The art is to identify these solvable and therefore simplified sub-problems. Other disciplines are now also starting to use this method. One example for this is that recently, a researcher at ETH modelled the behaviour of the crowd in Mecca during the pilgrimage. Instabilities of the crowd could be predicted from measurable quantities during the stable phase: mathematical language and statistics therefore enter into social sciences.

A fascinating problem is to understand human language. The difficulty is made obvious by the poor performance of language translation by machines. The ultimate goal is the machine translation of a joke and a machine laughing automatically at the right spot. This is so difficult to achieve because you have to understand the culture and history of a country. And there is also an emotional component, too. It is so complex, because it is much more than a pure linguistic masterpiece.

FUNDAMENTAL INVARIANTS

The question is if we can parameterize the culture of a country? It needs about 15 years for a child to become familiar with the basics of its own culture, religion and established prejudices. I believe that the deep truths of our world are the invariants, the similarities in religions and cultures. Fundamental truths are usually independent of time. These invariants are the research subjects a physicist is interested in. Once these invariants are known, the remaining parameter space of a cultural system or even civilization will be much smaller.

Figure 1: Wealth intensity versus citation intensity

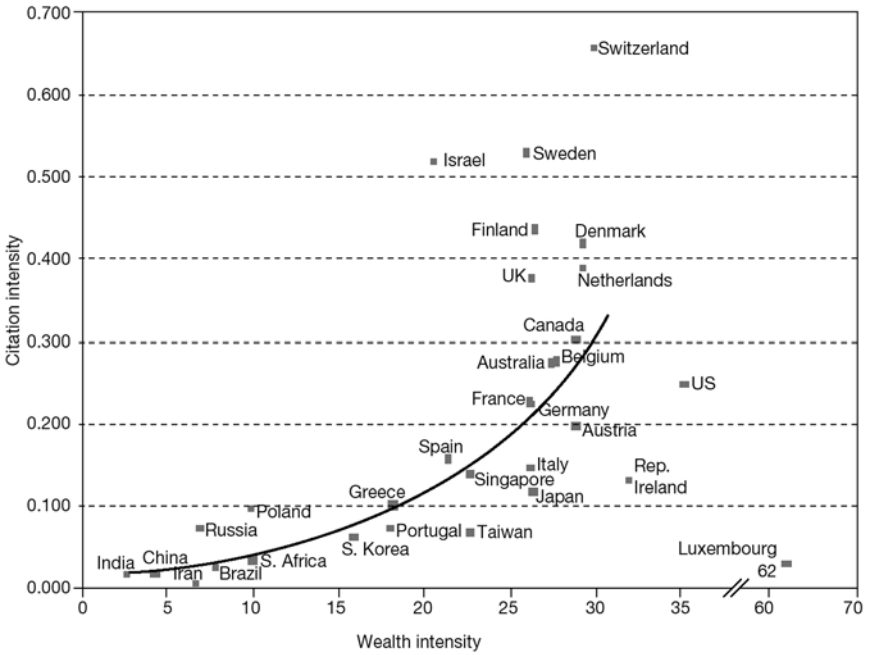

Figure 2: The Swiss dual education system

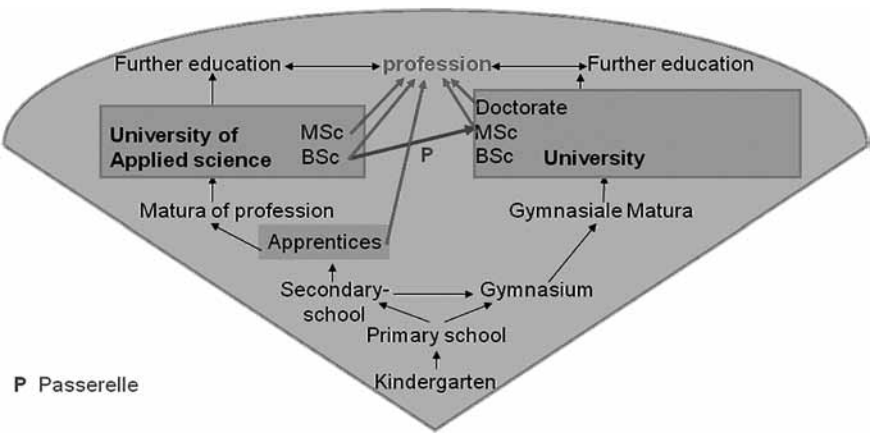

Figure 3: Upper secondary school graduation rates in 2005