On Education

New Year's Sunday News Special

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"Fortune favors the bold"

(hopefully)

Portugal's education system is geared towards developing the workforce for existing industries. It is not oriented to develop the next generation of bold scientific, entrepreneurial and social explorers. These are essential to develop countries as discussed by Lester Thurow in his book "Fortune Favors the Bold" (2003).

Our education is mostly based on an infection model, where the student infection level is tested in exams. The system filters students; it does not aim to develop them to be the best they can be.

This document attempts to pinpoint critical discrepancies of our school systems (primary, secondary and University levels) and those that have proven to create explorers.

Primary and Secondary School

(three takes on developing students to be the best they can be)

Breeding curiosity and creativity to create the next generation of explorers

EPIS (Empresários para a Inclusão Social) invited me to teach one of the worst group of students in the Lisbon area, some five years ago at a school in Quinta do Conde. They were in the 9th grade, but all of them were much older. Their social profiles were daunting. Most of them hated school, a place that they saw as irrelevant and/or humiliating for their lives.

However, their school had a special classroom fully equipped with computers. They had also professors that were trying to help them.

My first class was an absolute disaster. They spent the whole-time playing video games in the computers. My goal was to have them select an irritating problem they could solve, or a crazy idea they would like to pursue. Nothing happened. So, I asked them to think on the problems and ideas at home until the next class.

Again, the result was null. They kept ignoring me. They did not even consider doing the homework. So, I asked them to give me excuses. Not the real excuses- we all knew which they were. I wanted creative lies. Finally, I got their interest.

This school was the opposite of Liceu Pedro Nunes, where I had the privilege to study. Like many other schools in Portugal they were only trying to infect the students enough, so they could pass tests and exams.

At Pedro Nunes, we learned mathematical logic when we were twelve. That learning provided us with a mental model that could be applied or extended to all other disciplines. With those mental models, we can structure knowledge. Moreover, if one creates a solid knowledge base, one can venture creating new knowledge even at a young age.

I could not provide the mental models those students at Quinta do Conde were lacking in that limited period. I could however stimulate them in imagining problems and then realize the knowledge and skills they needed to solve them.

The success was limited: only two students showed that they could have had a much different school career (and even lives), in a better setting, even after their disastrous school experience. Those two showed to be highly creative. All of them should have been assisted much earlier in their schooling.

I still lecture occasionally in top ranked high schools in Lisbon. The students are far more disciplined. Actually, too disciplined. Their focus is to show at national exams that they were properly "infected". Very few students show the curiosity that leads to creativity. They are not clearly stimulated in that direction.

Of course, there are islands of exception. There are fantastic teachers around the country that inspire their students in science, technology and humanities.

There are also many independent initiatives. I know well two of the best. The Inventors (http://theinventors.io) is an initiative for mostly 8-12 years old kids that is having an impact in inspiring a new generation of explorers in science and technology. In the humanities, Republica das Letras in Terceira is stimulating yearly 40 students to read and discuss the Greek classics (https://www.dn.pt/lusa/interior/alunos-aprendem-com-os-classicos-gregos-na-ilha-terceira-9100679.html).

But we really need a dramatic change if we look to what is happening in the World. The most inspiring and game changing initiative is from the Korean Ministry of Science, ICT and Future Planning, Korea Foundation for the Advancement of Science and Creativity (KOFAC). Please see

https://community.computingatschool.org.uk/resources/5376/single?fbclid=IwAR3WkuYxHBOfr8MKUNjpUW6JBvzMqf5jisWIZ0_9vt0qAgL7LsP5nV3rPV0

KOFAC has produced ten textbooks for the Korean Software Education Module which cover cutting edge topics with integrated programming exercises, including hardware prototyping in the following topics:

1 Artificial Intelligence
2 Driverless vehicles
3 Internet of things
4 Virtual reality
5 CRISPR
6 Space launch vehicles
7 Natural disasters
8 Smart medicine
9 Game engines
10 Sports statistics

You can download the exceptional textbooks for educational use only. Note that these were developed for under 15-year-old youngsters.

This is an initiative that with minor adaptions to Portugal's needs and strengths could be replicated in our country.

Mental models for all

This Korean initiative is cutting edge: it stimulates the appearance of the future leaders in science and technology. Before such initiatives, I believe that we should strive to come back to the creation of structuring mental models, as the course "Theory of Knowledge" does for the International Baccalaureate program.

These three links show different approaches to knowledge that should be internalized by students (agreeing that some of the concepts should be only taught at the University level):

https://www.visualcapitalist.com/12-ways-smarter-mental-models/
https://fs.blog/mental-models/
https://tinyurl.com/ydaktvz8

One way to have students learning key mental models is to have them creating "legal" "cheat sheets" for themselves. There are plenty of excellent "cheat sheets" out there to inspire them. See:

https://www.cheatography.com/ (for all areas in high school)
http://www.cheat-sheets.org/ (for computer science and adjacent areas)
https://tinyurl.com/y8wuv9vk (machine learning and data science, areas that should be taught at secondary school level- see KOFAC documents above).

This is a structured top down approach. I also like a bottom up approach where the building of mental models starts by looking at ordinary places, objects and events. The Big History project is an example of such approach. See https://tinyurl.com/y7ygfq8o.

Such approaches will provide our students with structured knowledge of science, technology and humanities. No doubt, the best students learn how to derive it. But most students regard testing as a never-ending succession of rote learning exercises and charades they have to overcome with the same enthusiasm older generations had on ingesting cod fish oil.

Storytelling

My Department at NOVA FCT had an Erasmus program with Imperial College for many years. During my course, the Portuguese students excelled in problem solving in the class. But in the final project presentation, they looked like peasants when compared to the Imperial College students. They did not know how to tell stories.

I believe that the most significant problem in Portuguese education is rooted on the teaching of the language. See for instance the language arts goals at Brookline Public Schools in the Boston area

https://www.brookline.k12.ma.us/cms/lib/MA01907509/Centricity/Domain/58/Mass%20Curric%20Frameworks%20for%20ELA.pdf. Compare with the Portuguese Ministry of Education documents available at http://www.dge.mec.pt/materiais-didaticos-elaborados-no-ambito-do-pnep.

This problem is even more serious at a time where storytelling is evolving to multimedia environments. See BBC document at https://betternews.org/12-categories-digital-storytelling-formats/?fbclid=IwAR3DCnHJv1ZlpuXXD0Oa8AGlCMWl-lYGKG0t3o3jNf--XNrP-hEd94KPgj4.

Most of Portugal's top universities now address the communication problem. Students learn how to present Power Points. But telling stories requires that in the first place you read, watched and heard stories beyond the ever-shorter story segments available in the Internet (there are now "generated stories" available for almost any application). We have the National Reading Program in Portugal but little else.

College Education

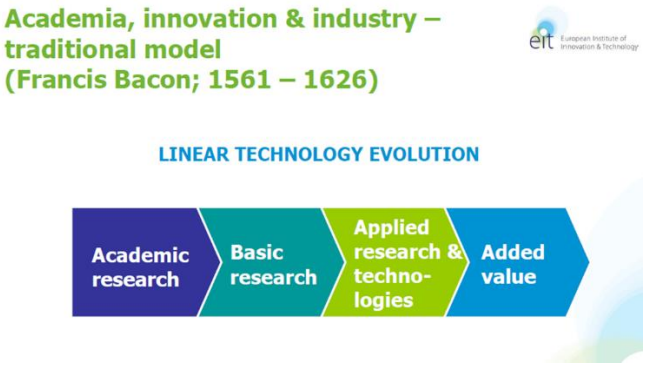
(creating a new generation of explorers)

How the (tech) World works

Portuguese Universities were mostly oriented towards the education of future employees of existing companies. In the last decade, they started changing by offering entrepreneurship courses and developing incubators. We have now vibrant startup scenes in Lisbon, Coimbra, Aveiro, Porto and Braga, the main University cities.

But Portugal has still significant talent retention, innovation practices and financial problems. The country has one of the worst international patent statistics in Europe (160 international patents are filed every year, comparing with the 4.000 Finland-with just 4 million people- files every year). We have had, in recent years, a problematic brain drain. There are schools and departments where most of their graduates work abroad. And our public debt is more than 125% of our GNP.

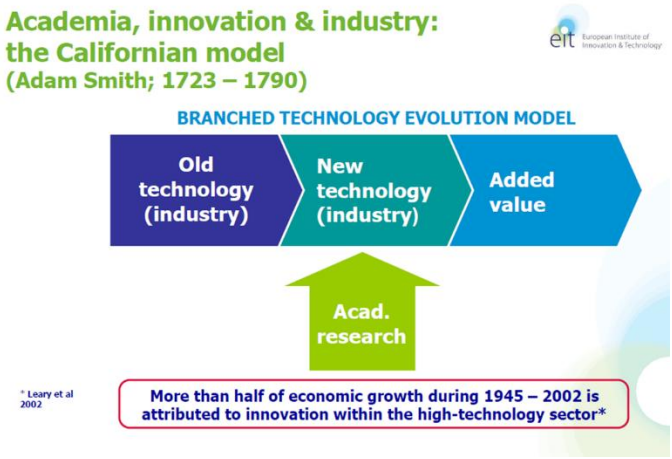
Our innovation system, like many others in the EU, follows the Baconian model as referred by Alexander Von Gabain, former EIT Chairman.



Actually, this was also the model envisaged by Vannevar Bush when he published "Science, the Endless Frontier" (https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm) that guided the development of US scientific establishment after World War II. This model is based on a social

contract: the society invests in scientific research hoping to be compensated later. This system has been questioned recently for its low productivity.

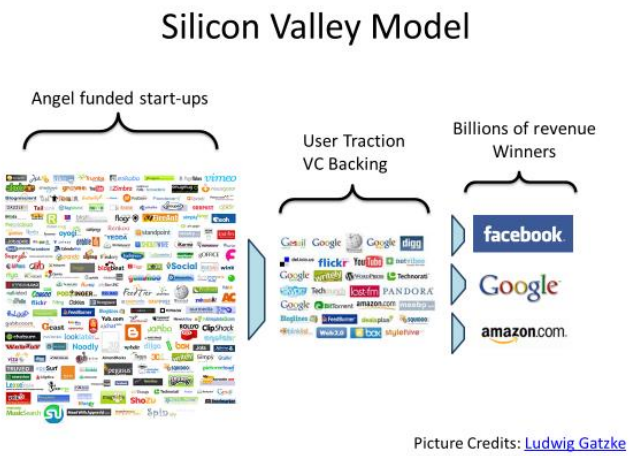
Karl Compton, his contemporary at MIT, led The Institute to also consider a different mission: the development of new industries (see https://hbr.org/product/creative-capital-georges-doriot-and-the-birth-of-venture-capital/1223-HBK-ENG). The innovation model became one based on technology change as shown by Von Gabain (that called it the Californian model)



This model has proven to be far more efficient. MIT is a living proof: its community developed companies that have revenues over 1 trillion dollars a year, employing almost 5 million people; and is associated to over 70 Nobel Prize winners. The European institute of Technology, led by Von Gabain, adopted this model, as many other institutions around the World.

Actually, this model was heavily financed by the US Government (see https://tinyurl.com/y9kheoxd) until this day (note the recent $480 million Microsoft Hololens order and the 10-billion-dollar Defense contract Amazon is vying for).

It enabled the creation of what is called the (Darwinian) Silicon Valley Model as depicted in this info-graphics



Picture Credits: Ludwig Gatzke

This model relies on entrepreneurs that create focused startups for both horizontal and vertical markets. Many of them fail at the angel funding level; few moves to VC backing; even fewer advance to the "winners take all" level. This is a model applied to any space (see for instance the Smart Cities space below) and, right now, in most of the World. CB Insights publishes regularly market maps for most areas (https://tinyurl.com/ycau6p2c).

"Smart Cities"

Exceptions to this VC growth model for technological companies are rare. Crowdfunding (both product and equity oriented) and listing in suitable stock markets for not fully developed tech companies (i.e, Toronto, Sidney and Frankfurt) are alternatives.

The University should continue its pursuit of knowledge driven by curiosity in every field. It also must continue teaching in many areas that may not be directly linked to this commercial view of the World (many of them essential for the new knowledge-based companies).

However, the understanding of current innovation models is essential for the Universities development and, above all, for their teaching, research and extension missions. The AIP report that I co-authored (see http://www.magicalindustry-aip.pt/benchmarking/) shows clearly how most leading universities in the US and Europe understand how the World (specially, the technological World) works as described above.

In the case of Portugal, we must adapt this model as the starting conditions (namely Governmental and EU funding, size of the market, and investor community) are not comparable to the US. We also lack the "information by osmosis" and "referral systems" available in the leading innovation hubs (https://tinyurl.com/yalngjw8). Portugal's programs with US universities were designed to, at least, solve partially these difficulties that are common to many European countries (Switzerland has now "tech Embassies" in leading hubs to help their research centers and companies).

To fully educate our students to thrive in this World our Universities must change at the entrepreneurship/exploring levels, but also at a much broader level.

Individual initiatives to develop explorers

I developed a course called Explora including idea generation, prototyping, intellectual property, communication, and financing (see https://myexplora.live/). Explora is based on my experience as a Professor for 36 years and Entrepreneur for 18 years. The course includes both "stock" concepts (key readings) and "flow" materials (links and tools) available at https://myexploralive.files.wordpress.com/2018/09/explora-versc3a3o-final.pdf.

Explora evolved to an online community with more than 100 members (I can add you at https://www.facebook.com/groups/183536175571026/). Twenty-five students from that community, at both NOVA FCT and FCSH, developed 14 preliminary projects for products (both hardware and software) that have market potential.

My goal is to transform Explora first in the equivalent to MIT's Sandbox (see http://sandbox.mit.edu/). Later, the goal is to create Explora Inc., an incubator/holding mix for new industries in the mold of Berlin's Rocket Internet (https://www.rocket-internet.com/). Experienced former students, YDreamers, members of the expatriate tech community now living in Portugal, and University colleagues are willing to help. Explora Inc. may become a financing arm of the University, as an evergreen developer of talent and ideas.

Initiatives like Explora complement entrepreneurship and other professional training courses. The Entrepreneurship course at NOVA FCT is one of the large in the World with its yearly 1000 students. It is part of a "Profile" set of courses that complement traditional engineering curricula (see https://www.fct.unl.pt/ensino/perfil-curricular-fct).

A broader view

There are several reports on the future of college (see https://qz.com/is/what-happens-next-2/1469287/future-of-college/) and a major study led my MIT on the future of engineering education (see https://tinyurl.com/ybjqkdog). Accenture has also produced a report specifying requirements for the future workforce (see https://tinyurl.com/y7989v8p). All of them point to similar directions:

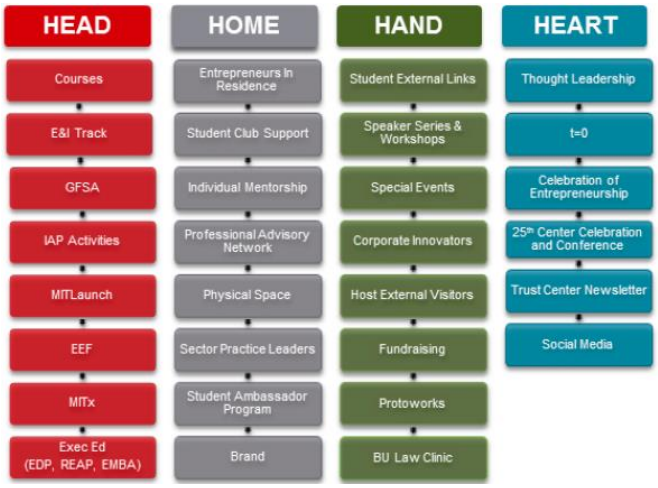
- University education was always about creating "stock knowledge" and prepare "flow knowledge" learning. "Stock knowledge" is changing: we are now data driven, instead of model driven; machine learning became an essential subject; and there are new developments in basic science that must be part of the curricula. "Flow knowledge" requires successive adaptations to new software, hardware and wetware tools;

- University students have to learn to be "makers" (see https://tinyurl.com/ydg59gbr), should do research as undergraduates (see http://uaap.mit.edu/research-exploration/urop) and have as much professional experience before graduating as possible. They should understand the opportunities provided by the so called "gig economy" (as providers and clients), see https://www.visualcapitalist.com/side-hustle-economy/;

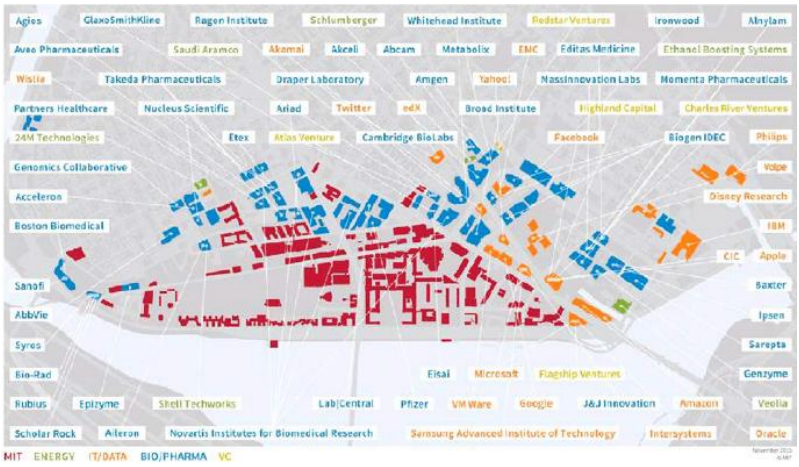
- Students have also to learn about entrepreneurship (which is already a compulsory course at NOVA FCT) but also understand about modern product and business development. Excellent resources, with an "industrial" orientation, are provided by https://productleadershipbook.com/, https://avc.com/category/mba-mondays/ and http://growth.eladgil.com/.

- Universities must operate in a World where there are hundreds of high-level free courses offered online (see https://tinyurl.com/y8bznagb).

- Universities must find ways to stimulate the creation of new industries by partnering with old industries and stimulating their development in their communities. The incentive to attract existing companies and develop new ones on campus is ever present in leading Universities (see, for instance, http://entrepreneurship.mit.edu/ represented in the following flowchart



- As a result, University campus are now surrounded by companies creating Innovation Hubs. This is clearly the MIT case:



The proximity of companies and investors to a University translates into employment for University graduates, training for students, research funding, and a critical mass that enables the continuous creation of new companies.