SCENARIO I. GLOBAL COMPETITION (Science as Culture)

Content

Preface

This scenario is based on a world which is shaped by constantly progressing technological innovations and a competitive and likewise flexible labour market. Essential prerequisites for competing personally and professionally in 2030's environment are readiness for lifelong learning and distinct self responsibility. These skills are even more important when considering that a publicly funded welfare system does not exist anymore, and people have to cover these expenses from their incomes. In the following implications on the economy, technology and daily life are described for the world and particularly for Luxembourg. They provide the contextual environment for a new science-based education system established in Luxembourg which prepares individuals to most efficiently and successfully manage their private and professional lives and enable to behave like an individual entrepreneur.

I. The world in 2030

Over five centuries, Europe ruled most parts of the world and dominated on global trade markets: The 19th century was the century of Europe, the twentieth became the American Century with Europe an active partner. However, by 2030 the prediction of the 21st century going to be the Asian Century became true[1]. In the new millennium, economic globalization continues on Asian terms: The contribution of Asian industry to global gross domestic product has leapt from just over 24% in 2013 to nearly 50% in 2030 (Figure 1), driven mostly by China and India. Economic dominance has shifted eastwards and with this a new global order based on Asian values of societal order and working conditions is imposed on former developed countries which are forced to adapt if they do not want to be left behind.

High-skilled professionals and cutting edge technologies overstock the international market creating strong competition. This has had radical impact on the European lifestyle previously experienced during boom years. Severe cuts in the social system and significantly lower wages made middle class families struggle. Companies regard filling a job like buying a spare part. Job markets worldwide have adapted to the shifts of economic power and have become extremely flexible. Individuals are exchangeable and are thus considered as commodity unless they keep up with the technological developments on a constant basis. As such flexibility and lifelong learning are the only way to ensure relative job-safety people dedicate a large percentage of free-time to self-education in order to remain relatively relevant.

'Big Data' and the 'Internet of Things' are worldwide megatrends: everything and everybody is interconnected as well as tracked, traced and databased. While privacy of personal data became an outdated concept and people value the service and benefits they have in sharing their data, governments of leading economies in concert with companies strengthened intellectual property laws to protect and further encourage release of innovative high tech products and goods.

Europe's economic downturn had been *the* landmark event of the last two decades and its impact, whilst unevenly spread, can be felt across the whole continent. A select few countries, including Luxembourg, whose attitude to change has been proactive appear as leaders in an EU characterized by a less strict regulatory framework which cooperates primarily on economic issues in order to compete globally. Less competitive countries, so called followers, adapt slower to global economic trends.

[1] The International Economy Magazine, 2013, The Asian Century: Reality or Hype, Summer 2013 issue; http://www.international-economy.com/Summer2013archive.htm

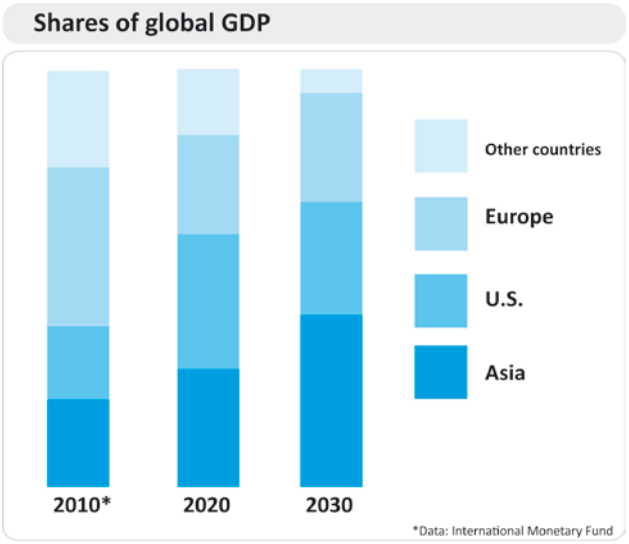

Figure 1: Shares of global GDP of Europe, U.S., Asia and other countries in 2010, 2020 and 2030.

I.1. Geopolitical issues and energy

By 2030 the world population has reached 8.2 billion people[2]. Energy and water resources have become more and more exploited and food production has risen accordingly. Despite a rising demand in food, energy and water a severe supply crisis has so far not materialised due to concerted political action and technological innovation, but it remains a key concern. Energy demands are met through a mix of renewable and fossil energy. Large photovoltaic installations in the Sahara and offshore wind parks produce electricity distributed to European and Asian metropolitan areas. New exploitation methods secure world's energy needs, and to date there have been no catastrophic incidences of harm to the environment (e.g. oil spill). Technologies for water filtration and treatment of waste likewise benefit from innovative research and prevented major water crisis and conflicts. However, today in 2030, the demands of food, energy and water rely on constant technological progress to keep pace with fast growing world population and claims for resources. This development forces countries worldwide to invest in research and development of methods for prevention of severe environmental damages and to implement political framework for safeguarding the environment.

I.2. Global leadership and power distribution across governance levels

Successful global players are countries with a governance system adapted to the highly competitive and dynamic world market. In a climate of competition China and India set the standards in the course of their emergence as strong economies. While multilateral pacts disassemble in Europe, Asian states enter new alliances. Bi- and oligo-lateral treaties are negotiated based on the ideal of a free market economy with well-defined but pragmatic and regulations which are easier to monitor. Pacts, similar to what had been inaugurated under the TTIP[3] in the second decade, exist between East-Asian states but also involve U.S. and prospering European states. These treaties enable free trade of specific goods between selected countries but in general states are competitors.

In 2030, the dream of a strong unified EU is over. During the financial crisis two decades ago, the EU could not provide the expected economic shelter for its member states. Companies based in these states were stuck between inflexible EU criteria, (e.g. long lasting patent registration processes, import and export tariffs, labour laws, etc.) whereas those outside the EU could adapt rapidly to novel forces on the world market. EU's rigid and anachronistic regulatory framework was considered as the main cause for economic decline. As a consequence nations with proactive national leaders became more

[2] United Nations, Department of Economic and Social Affairs, Population Division (2006). World Urbanization Prospects: The 2005 Revision. Working Paper No. ESA/P/WP/200. Factsheet 4.
[3] TTIP: http://en.wikipedia.org/wiki/Transatlantic_Trade_and_Investment_Partnership

inward-looking, joining their political and financial forces in a quest for their individual economic success on the global stage.

While most EU countries fail, a handful of nations made the leap. Luxembourg, Germany, the three Scandinavian countries and The Netherlands emerged as strong nations. Equipped with significant economic power these countries took over the leadership in the EU. They shape 2030's regulatory framework and restructured legislation towards fewer and less rigid laws and rules, which allows for both: adapting to the free market economy with rigid austerity measures, and still cooperating to be globally competitive. This cooperation is not simply economic, but also technological, encouraging innovation and entrepreneurship at every level. It therefore also impacts upon issues of skills and education.

The African continent and South America remained in similar positions they hold two decades ago. They are still not shaping today's world, but since China became a hot spot for research and development with rising labour costs, many production sites were relocated to African countries.

I.3. The global economy and free trade

In 2008 Europe was thrown into a financial crisis followed by a deep and prolonged recession. During the following two decades it was 'survival of the fittest' at its best. Many well-established Western economies declined while former emerging countries rose to prospering markets based on highly demanded innovative high-tech goods developed by young high-skilled and motivated workers.

Continuous economic instability cumulated in the collapse of a range European economies splitting Europe into two categories: strong and weak economies. Rigid EU regulatory framework and procrastinating politicians debarred most EU member states from necessary reforms of their labour market and social systems and thus, from keeping pace with the rapidly changing rules of the world market. Ongoing recession went hand in hand with lower incomes and changed consumer preferences accelerating the decline of these economies. This created some turmoil in affected regions but no severe conflicts.

Strong countries (e.g. Luxembourg, The Netherlands, Germany and the three Scandinavian states) followed a similar path: with the beginning of the new millennium they diversified their economic portfolio through investment into research and development, imposed rigid austerity measures and had a significant impact on EU's agenda and framework. Steely-eyed commitments from policy-makers (cuts in social welfare system, lowered wages etc.) and an attitude of 'work hard and work long' among the population made it possible that these countries became main drivers shaping the technological revolution. National leaders motivated their citizens to re-build the countries on the basis of the Asian and American system, adapting to a free market economy. European countries with a focus on previous niche markets (e.g. smart e-devices) persisted and expanded over the years until 2030, as they were copying the Asian and American ways of processing goods more resource-efficient and thus at lower costs.

The U.S. economy suffered during the era of financial crises but recovered successfully and maintained its hegemonic position on global markets. Companies, such as Google and Amazon with a focus on innovative research and development and relying on a repository of patents for high-end technological products, emerged as winners.

Asian economies experienced a rapid rise over the last two decades. The economic downturn in Europe has helped to promote re-thinking in terms of consumption of traditional status symbols. Emerging Asian economies (e.g. China, India, Taiwan, Malaysia) focused on the development of resource-efficient objects and devices for an interconnected world instead of trying to catch up with the Western world's idea of mass consumption. China propelled into an economic powerhouse by no longer exporting low-cost commodity type goods (shoes, clothes, toys etc.) but competitive high-tech products for a global key market. Production of cheap goods switched to Asian low-cost countries (Myanmar, Laos) as well as to parts of the African continent.

The entirely information-based Asian society demands smart products to succeed in an interconnected world, and moreover, these goods are regarded as highly prestigious and outweigh traditional Western status symbols. Brands became less dominant because the value of a good depends on its country of origin and on the benefits it provides to its user (e.g. zip car, smart e-devices etc.). A co-production of Chinese Shuanghuan Auto[4] and Google[5] yielded an electric self-driving smart car specifically developed for Asian megacities. European cars do not meet the criteria to solve traffic-related problems such as pollution and massive congestions. The severe impact of this dramatic decrease in demand for cars produced in Europe ruined automotive manufacturers and their subcontractors in the five largest European economies (U.K., Italy, Germany, France and Spain).

Science education and innovative entrepreneurship were the main drivers shaping Asia's success. As a reflection of increased scientific expertise, high tech exports from Asia took off, growing by a factor of 20 only from 2020 to 2030. Since the early 2000's the same number of citizens of East Asian countries received engineering PhDs from American schools as U.S. citizens did[6]. Asia's young generation is characterized by anxiety for information uptake and ferocious desire to learn, semester-long course in U.S. are taught in five days in China[7]. Centres for educating the new elite shifted to Asia. Highly skilled graduates are trained in their home countries with emphasize on key disciplines in order to serve the domestic research, development and innovation industry.

Asian companies install branches of their rising companies in Europe and become major investors. They implement new world market rules and impose their Asian ethos of working, learning and self-mastery on Europe's society. Thus, from an East-Asian perspective the European crisis was a beneficial economic catalyst drawing off global economic power from Atlantic Time zones to Pacific ones. Figures 2 and 3 summarize and illustrate driving forces and events shaping the world in 2030.

I.4 Labour market

Traditional jobs and permanent corporate employment are reminiscent of the last century. Around 20% percent of the working population are freelancers offering their skills and expertise on-demand. In 2030 economic freedom and professional career depend on skills such as exhibiting initiative and willingness to take risk, i.e. an attitude of self-organization and self-entrepreneurship. On-demand economy has steadily grown since the early 2010's when with the help of an app customers were brought together with service providers such as the chauffeur provider Uber. By 2030 an army of self-employed specialists and auto-entrepreneurs (lawyers, economists, teachers, medical doctors, craftsmen etc.) is ready to offer expertise and recent technologies enable to easily match jobs to workers and vice versa. Companies offer prizes to freelancers to solve their R&D problems, similar to what Colgate-Palmolive did in 2012 when the consumer-goods company offered 17,000 to anyone who could develop a 30-second advertisement for the internet. In such a working environment people will have to learn to sell themselves via social media, update their knowledge constantly, built networks and collaborations: "in a more fluid world, everybody will need to learn how to manage You Inc."[8]

In 2030 the global competitive climate shapes working environment, which has nothing in common with Western European welfare-based conditions two decades ago. To remain competitive companies have worldwide offices and rely on continuous exchange with their customers and business partners located in different time-zones. Core time does not exist anymore but employers expect from their workers to be on stand-by all day.

People work full-time to be able to cover increased expenses (e.g. expansive rents, private social security and health care). Over the last two decades, a new 'super' working-class has emerged which sees work as the purpose of life and regards leisure time as a sign of laziness. This attitude was influenced by values prevailing in the emerging Asian countries, where forgoing of personal freedom for

[4] http://www.hbshauto.com/
[5] http://googleblog.blogspot.com/2014/05/just-press-go-designing-self-driving.html
[6] www.nsf.gov
[7] William Easterly, The White Man's Burden, Oxford University Press, 2007, p.310.
[8] Workers on tap, Economist January 3rd, 2015.

the sake of society's stability and prosperity, pursuit of academic and technological excellence and a strong work ethic together with thrift have shaped social order[9].

Despite a few niche-experts, working for a longer period on a single subject or project is rare and a new form of more flexible work in terms of location and working hours replaced traditional employment and steady state professions. Most humans fulfil criteria of so called 'T-shaped' workers with deep expertise in one or more disciplines while being conversant across a range of others. As previously mentioned, people work on temporary contracts for on average four years which rarely are converted into permanent ones but rather are prolonged for another period of two or four years. For young employees without families it is not unusual to change a position or country of employment frequently. It is a generation of working nomads with no close ties to their home countries.

Recently, this culture of 'working hard' has been challenged, at least in some Western European countries. Here, people started to escape from the treadmill of a 60 hours work week and of dedicating their life completely to work. Skills such as an entrepreneurial attitude, self-esteem and self branding together with establishment and managing of social and professional networks, that had been significant elements of recent curricula at school and university, enables people to regain ownership of their own destiny.

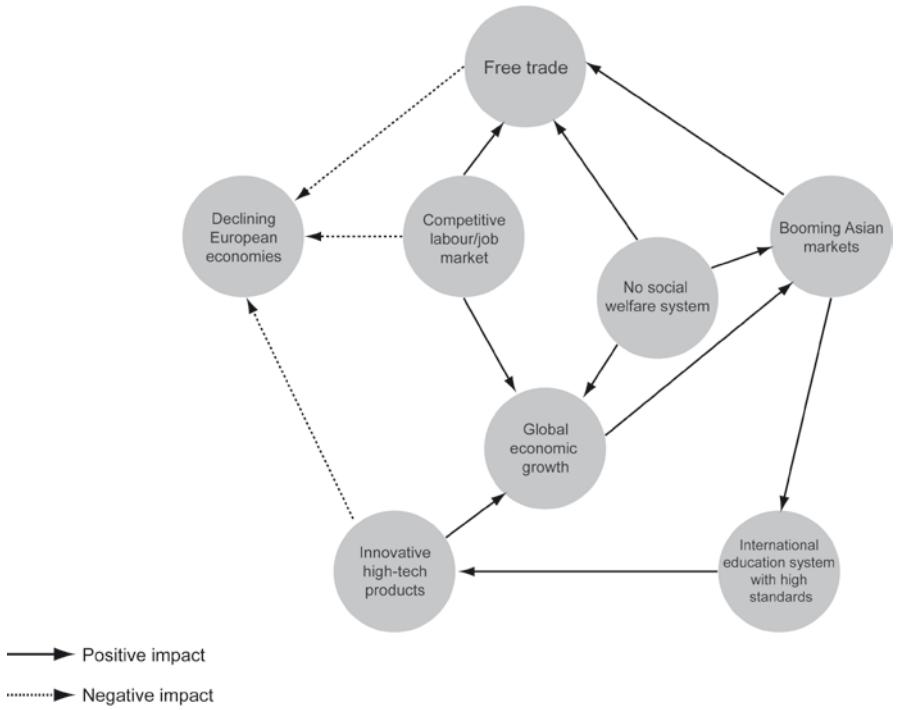

Figure 2: Systems diagram - what stabilizes this world?

[9] Definition of 'Asian values': http://en.wikipedia.org/wiki/Asian_values

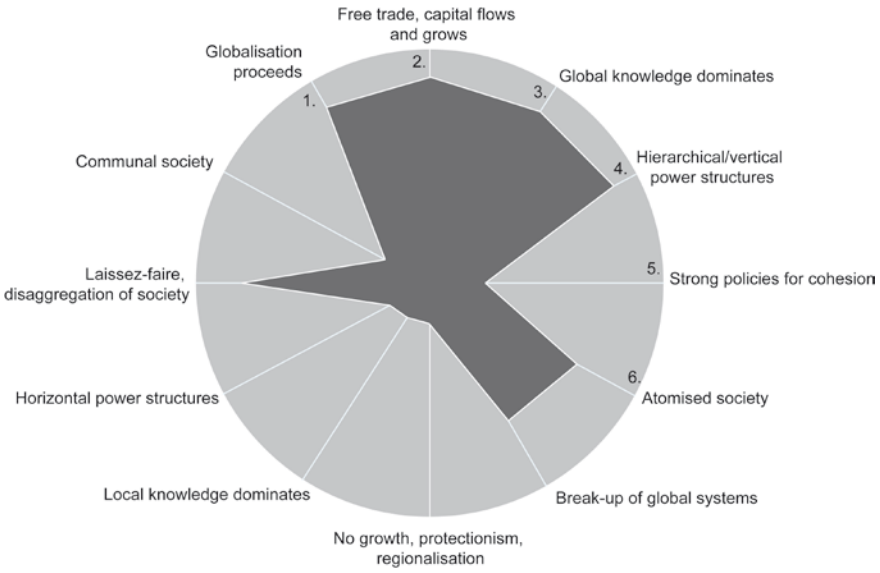

Figure 3: Axes of differentiation.

II. Luxembourg in 2030

While many European states are still suffering from the crisis Luxembourg made the leap to a prospering economy. After half a century of building up the financial sector, in the beginning of the new millennium Luxembourg started to diversify its portfolio by investing into emerging sectors such as bio- and eco-technology, ICT and logistics – a strategy which paid off well. Nevertheless, Luxembourg could only follow its path of unhindered technological progress by obeying to global rules set by leading states such as China. Thus, severe cuts in social welfare and attraction of high-skilled workers were inevitable creating an atmosphere of strong competition. Main events in the world and in Luxembourg from 2010 to 2030 are presented in the timeline below (Figure 4).

Timeline

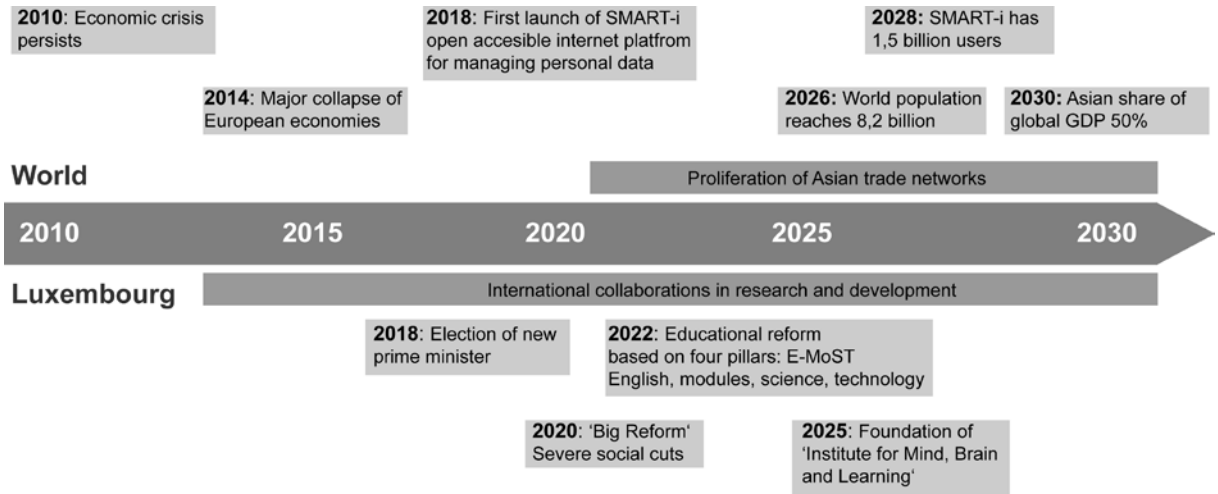

Figure 4: Timeline with landmark events shaping the world and Luxembourg.

II.1 Society

In 2030 Luxembourg's population has grown up to 700,000 inhabitants. Everyday 230,000 commuters from France, Germany and Belgium stream into the country using smart public transport. A person's

citizenship is of low relevance as long as it is one of a wealthy country, which allows for almost borderless travelling and not being considered as a refugee or poverty-driven migrant. Getting the citizenship of a prospering state such as Luxembourg depends mainly on qualification. Agreements between Luxembourg and other leading world economies enable flexible exchange of high-skilled employees. Technological advances in biometrics and overall transparency increase the capacity of countries to control entry.

It was not a pain-free road to Luxembourg's economic success. In order to keep pace with constantly changing global conditions Luxembourg's prime minister, who had been elected in 2018 and benefitted from wide support, implemented a reform in 2020. Among citizens it was coined the 'Big Reform' because it brought about 'big' changes. Social welfare, health care and civil servants system were partially turned down and citizens suffered from severe financial and social cuts. However, this was the only way to catch up with an accelerated world economy. Health insurance is offered by private companies only and people pay into pension funds themselves. These circumstances triggered people's willingness to pursue a more preventive and healthier life style. Self-ownership of and self-responsibility for health (self-monitoring and self-treatment), personalized medicine and major breakthroughs in disease treatment (e.g. new pharmaceuticals) compensate partially the missing social welfare system.

Luxembourg attracted many high-skilled professionals to work in research centres and think tanks, which created an atmosphere of strong competition on the national labour market. Incomes in Luxembourg decreased significantly due to salary transparency and a strict austerity policy. A harmonized labour market across borders meant that primary school teachers in Luxembourg no longer earn more than a university professor in Metz or Trier. For a country which for decades ranked among the top ten countries with highest average salary, this meant sharp financial cuts for middle class families. As a consequence families rely on double income to be able to cover all expenses.

Incomes are partially success-dependent and despite a small yearly increase to alleviate the ever augmenting living costs, they are not index-linked and hardly cover all expenses. Often people hold two or more positions, work as freelancers on projects and are involved in studies and entrepreneurship at the same time to diversify expertise and demonstrate flexibility. This is not predominantly for prestigious purposes and a sign of work ethos but mainly a means to an end: low incomes and high living costs require that people have an extra-income to pay for social expenses not covered anymore by the state and to able to afford *e.g.* costly childcare. There is almost no employment certainty in this world, and there are growing numbers of entrepreneurs that choose the high risks in pursuit of high potential rewards. Less skilled people not fulfilling demanding criteria to work in research and development benefit from Luxembourg's relative economic prosperity as they are employed in public or private service providing companies (army, civil and community services etc.), which keeps Luxembourg's unemployment rate on a low level.

Luxembourg's regional development during the last decades has mainly been characterized by an increased urbanisation and establishment of the so-called 'tripole' consisting of the cities Esch-sur-Alzette, Luxembourg-City and Diekirch-Ettelbrück ('Nordstad', city of the north). Small villages become more and more extinct when people began to move in close proximity to their employers, e.g. global companies or administrative institutions located in infrastructure-rich city centres. Decentralising the country by establishing sub-centres and empowering the northern part have been two major goals of Luxembourg's regional development. The rise of the Nordstad to an infrastructure rich and economically sustainable city in the northern part of Luxembourg began with the settlement of the 'Administration of Nature and Forests' in Diekirch in 2015[10] and ever since has been followed by several more relocations of key administrative institutions from Luxembourg-city to Diekirch-Ettelbrück. The goal of 7,000 more jobs by 2020 had been achieved and another 2,500 jobs were created by 2030.

In the tripole cities demand for urban living space increased which together with relatively lower salaries compared to the beginning of 2000 resulted in denser urban living. People inhabit smaller and

[10] Luxemburger Wort, August 27th, 2014: „Neues Verwaltungsgebäude der Administration des forêts et nature in Diekirch – Wegweisend für nachhaltige Bauweise.

more condensed living-spaces. The space conundrum had been solved by clever compartmentalization and foldable furniture stored in the ceiling which transforms a room into several different set-ups (dining room, living room, office etc.). Recently, the first apartment buildings with micro apartments[11] of 40 and 20m^2 serving four-member households and single persons, respectively, had been built in Luxembourg.

The controversial implementation of a self-driving tram line[12] in Luxembourg City paid off well and in 2030 serves to transport people to their work. Digital services use transport data to compute most efficient ways of travel and commuting usually as a mixture of public-transport and co-sharing of cars and e-bikes. This smart combination of transport vehicles prevents traffic jams, saves parking space, guarantees that people reach work in time and makes transport affordable.

II.2 What are the driver's in Luxembourg's economy

Luxembourg is globally renowned for its expertise and innovative research and development in the sectors of life sciences, biotechnology as well as information and computer technologies (ICT). This portfolio ranks Luxembourg's economic performance among the top ten countries on the GDP list. In the course of Luxembourg's 'Big reform' in 2020 a governance system was established that tore down most national regulatory work and dissociated from the EU and its regulations (e.g. flexible and fast patenting processes, less restrictive GMO legalisation etc.). EU institutions left Luxembourg and the financial sector downsized leaving empty buildings and office space, which promptly were occupied by start-ups from the technological sector, research laboratories and branch offices from international companies.

Just recently in 2028, Luxembourg's efforts to become a world leading hub in life sciences and biotechnology bare fruits. Luxembourgish neuroscientists working partially at the Luxembourg Centre for Systems Biomedicine (LCSB) and the Integrated BioBank of Luxembourg (IBBL), together with colleagues from China and the U.S. made a revolutionary discovery to prevent the outbreak of Alzheimer. A Luxembourg-based pharmaceutical company, partially owned by the state, researchers and a corporate shareholder, was right in place for commercialization of the new product that was more than awaited by an ageing world-population. Due to low regulatory framework on the world market and novel testing methods the new pharmaceutical was launched in mid-2029 and since then indirectly filled Luxembourg's public purse. In this climate researchers became successful entrepreneurs seeking to gain profit from their findings. They set up partnerships with venture capitalist firms, of which there are increasing numbers based in Luxembourg due to its benign financial climate. Today, scientists have escaped from their role as 'weird scientists', become increasingly financially astute and thus have become drivers of Luxembourg's economy.

A further success story is LCSB's involvement in the American BRAIN initiative[13]. Research findings from this fruitful collaboration brought new insights into learning and education methods and resulted in foundation of the 'Institute of Mind, Brain and Learning'[14] on Luxembourgish ground. The institute's mission is to be at the interface between research and educative practice and to make Luxembourg world leading in educative science. A major outcome has been the biometric classroom, a project in collaboration with MIT and with support of Luxembourg's innovative sensor technique industry.

Besides biotechnology, 'Big Data' and the 'Internet of Things' are worldwide megatrends. A key technology is SMART-i (see Infobox 'SMART-i'), a joint venture of Luxembourgish, American and Chinese expertise in state-of-the-art programming, data-mining, chip design and bio-technological sensor technique. With participation in SMART-i Luxembourg finally established at the forefront of world leading economies. SMART-i owns all data and therefore can recognize habits and behaviours which serve as ideas and inspiration to create new trends and respective new marketable products.

[11] Micro apartment: http://www.narchitects.com/frameset_MMNY.htm
[12] Luxembourg tram: http://www.luxtram.lu/
[13] BRAIN initiative: http://www.nih.gov/science/brain/index.htm
[14] Dee Dickinson: http://education.jhu.edu/PD/newhorizons/future/articles/imagine/

The personal portfolio in the internet: **SMART-i**

In the interconnected world SMART-i manages and organizes people's lives most efficiently and is indispensible for survival in a complex rapidly changing environment.

SMART-i is a personal digital folder in the web on which all data related to a person's life and activities from birth onwards are stored. Data about a person's actual position, its genetic fingerprint, health data, school record, information on competencies, employment contracts, work experience, financial matters, biorhythm etc. is stored therein and constantly accessible, also by employers, state, bank, teachers, parents, doctors etc.

SMART-i's possibilities are most efficiently exploited in combination with a smart watch and wearable chips, so called 'wearables'. The smart watch is like a tablet PC worn around the wrist upgraded with sensors. Wearables are washable microchips sewed into every piece of clothing equipped with sensors and a microphone to gather information about the person (e.g. health parameters) and its surrounding (conversations, air quality etc.). Information recorded from these sensors is constantly uploaded on SMART-i and processed by specific programmes and algorithms. The generated output can be a recommendation for uptake of specific nutrients, warning about high blood pressure, a reminder to finish off a task at work or to attend a lecture at school etc.

Pictures: SMART-i interface, smart watch and wearable chip

However, it is not just about data gathering and collecting. Vast amounts of accumulated data from interconnected devices also rely on smart processing. With its Interdisciplinary Centre for Security, Reliability and Trust (SnT)[15] Luxembourg is right in place to provide adequate software and devices to deal with processing and storing as well as security and reliability of these dominating systems. This is particularly relevant against the background of protecting intellectual property, a key factor in the global technology driven economy. The Luxembourg Intellectual Property Office is now one of the main patent offices in the world, closely affiliated with the German Patent Office. The two offices now share the resources of what was once the European Patent Office, creating closer and more efficient links between scientific research, business innovation and technological diffusion. The Luxembourgish economy thereby further accelerates its rapid scientific evolution and boom.

II.3 Prevailing household family structure

Family life has considerably changed. Work makes life meaningful and therefore people are engaged in work in some form or another almost every moment, while traditional families became an outdated concept. Work and school have taken the role of family and socializing takes place at work and in the virtual space via networks.

The majority of children have parents who are both working in full-time positions. This is also to be able to cover expenses for childcare and extra-curriculum trainings; therefore, hardly anyone has more than one child. Children attend school eight hours per day and five days per week because curricula are tough and learning targets are high. Their parents work similarly long which does not leave much time for private activities. The picture of a family gathering around a table for dinner is a privilege for those who can afford to work less or is reserved for the weekends. .

Recovery, especially from demanding work, follows latest trends in brain research and is highly efficiently organized. Based on the immense technical progress in medical research, once per month people spend twelve hours in a cubicle-like compartment called 'recovery-unit'. During that time they are sedated and treated with a sequence of light and acoustic signals together with electronic impulses stimulating the brain and muscles. These units are usually owned by employers and recovery sessions are offered free of charge to ensure workers mental and physical fitness and thus prevent

[15] http://wwwde.uni.lu/snt

non-productive time through e.g. cardiac diseases and psychological disorders (e.g. burn out). During such a recovery process data of personal health are gathered statistically analysed and recorded.

Retirement is prolonged to the age of 68, due to a higher life expectancy (innovative preventive health care, enriched food etc.), a weak welfare system and increased living costs. People cannot pay into a pension system but have to take care of their financial coverage themselves. Moreover, 'being retired' is not appreciated in society and considered as weakness and professional failure. However, retirement homes do exist and benefit from latest research findings. They are highly automated with robotics for entertainment, occupational therapy, medication etc. and efficient pharmaceuticals exist to cure and ease most diseases of elderly (Parkinson etc.).

II.4 State of environment

The prevalent perception in 2030 is that the environment is in a better state than 30 years ago. This is partially true because all over the world a more prominent virtual environment decreased physical consumption and lower incomes in former prospering European countries make people consume less. Emerging countries developed prosperity on the basis of resource-efficient and relative environmental friendly technological innovations: E-cars dominate as means of transport in Asian megacities and Luxembourg provides a smart public transportation system as a combination of tram, zip cars and E-bikes, which significantly improved environmental health. By 2030 the world population has reached 8.2 billion people. Therefore, energy and water resources are more and more exploited and food production rose accordingly. Despite a rising demand in food, a severe supply crisis of energy or water has so far not materialised, but the threat continues to loom large. Vegetables are produced in resource- and energy-efficient multi-storey greenhouses together with insects for human protein rich-diet relying on interconnected nutrition cycles. Meat is produced artificially in in-vitro cultures so that cattle herds and fattening stables have disappeared. Meadows and pastures either interlaced or were converted into agricultural land for crop production and thus, agricultural area for nourishing 8.2 billion people only increased by 10%. In Luxembourg crop production has been almost completely abandoned, except for some intensive horticultural production sites in close vicinity to city centres, after EU subsidies had been cut down. The remaining fallow land and areas affected from mass migration to cities are turned into nature protective areas. These zones augmented significantly in size and vast almost un-fragmented habitats remain which are GPS mapped and provide precise annotated data for species incidences. All wildlife mammals are equipped with chips to track their position, which minimized wildlife crime. Sequenced genomes exist for every species and advances in cloning and stem cell research even enabled resurrection of some extinct species.

Environmental awareness such as two decades ago does not exist and environmental issues do not play a dominant role as people are mainly concerned with organizing their challenging private and professional lives. Environmental issues are targeted if quick-fix solutions and matching technologies are available. Forecasting models based on huge data sets together with sensitive sensor technique enable reliable prediction and prevention of natural disasters such as floods, earthquakes, tsunamis. Nature and its biodiversity are regarded as a large repository consisting of fitting parts for technological innovations, e.g. microbes acting as biological sensors.

II.5 Science, technology, knowledge

Amongst the Luxembourgish population there is immense trust and pride in the contribution that science made to be part of the technological revolution and keep pace with rapid developments on the harsh world market. To honour scientific achievements and to further promote the importance of science the Ministry of Higher Education and Research launched the campaign 'Big Science from Small Country' to nurture talent and interest in scientific endeavours and to bridge careers in the science and technology sector.

In countries such as Luxembourg with its prospering economy and industry, new technologies emerge at a speed surpassing most people's ability to realize it. Their impacts continue to shape day-to-day

practices even more strongly than most had thought. Robotics and machines replaced human jobs but programming is still in hands of human programmers. While expanding to megacities the urban environment experienced a face-lift: self-driving zip cars and high speed trains dominate as means of transport and drones transport goods within the city[16]. Smart buildings equipped with microchips and highly efficient photovoltaic cells shape appearance of streets in 2030.

In 2030 Internet of Things[17] (IoT) rules the world: everything and everybody is interconnected as well as tracked, traced and databased. Every object is equipped with sensors and chips (buildings, pavement, busses, machines etc.) and data is collected constantly and accumulating to *big data*. In a 'microchipped' environment privacy became an outdated concept. Technological innovations such as SMART-i take control of people's private and professional life. While there was considerable concern among citizens about massive data collection and storage through states and companies two decades ago, this fear is completely wiped out among the generation who grew up in a physical and virtual world. Giving away personal data in exchange for tailored services and products is valued by people who are mainly occupied with facing everyday's challenges of competitive work environment and achieving constant personal progress. In such an environment, a profound understanding of scientific and technological knowledge is essential to sustain in private as well as professional life, and education has to provide a base to this.

In an environment of rapid technological progress in which new innovations are main drivers of national economies, personal data is free accessible and China is a main actor the question about intellectual property (IP) rules and international binding patent laws becomes prominent. While a few decades ago intellectual property violations, especially in automotive and electronic industries, had been an issue in China and companies had been calling for stronger IP protection, in 2030 Chinese companies are calling for the same. With Chinese firms expanding overseas they also invested heavily to develop and protect their original technologies. Moreover, a recent publication by the World Intellectual Property Organization (WIPO) called 'WIPO's map to 2050' had been developed in close collaboration with SIPO, the Chinese IP agency, setting high standards for IP rules and high penalties for their violation. Luxembourg's economic development relied on these developments of protected and international binding IP rules.

III. Luxembourg's school system

Worldwide developments and the business climate after the crisis in 2008 set particularly high standards for a new education system (Figure 5). In Asia a new high-skill low-wage generation has been raised which sets high standards in terms of qualification and puts strong competitive pressure on jobseekers from former developed countries. These elite workers attended schools reflective of 2030's economic and societal structure. Classrooms are upgraded with recent technological innovations from local industries, courses are held in English and a broad choice of online course work and lectures, mainly in science, technology, engineering and mathematics (STEM) disciplines is offered. Value education emphasizes discipline and self-centred education. These mainly Indian and Chinese pupils face conditions resembling their future working environment and thus, are perfectly adapted to working life in 2030. They show strong commitment and dedication to work with a willingness and enthusiasm for acquiring and up-dating knowledge constantly.

Luxembourg's educative reform was driven by the aim to best educate and prepare young people. The contextual environment is characterized by the patterns described before: there is a strong competition on the markets for labour and goods. The global economy is dominated by Asia and driven by free

[16] http://www.delivered.dhl.com/en/articles/2014/04/tomorrow-s-transport.html

[17] Internet of Things, IoT: "The basic idea of this concept is the pervasive presence around us of a variety of things or objects – such as Radio-Frequency IDentification (RFID) tags, sensors, actuators, mobile phones, etc. – which, through unique addressing schemes, are able to interact with each other and cooperate with their neighbors to reach common goals." In: Luigi Atzori, Antonio Iera and Giacomo Morabito, 2010, The Internet of Things: A survey, Computer Networks, 54, 2787-2805.
Example: A smart fridge keeps track of availability and expiry date of products and automatically places an order if a specific good runs out.
See also: http://www.technologyreview.com/news/527356/business-adapts-to-a-new-style-of-computer/

trade and technological leadership. There is no public welfare system in place and temporary employment is prevailing. Big Data has become an essential feature in daily life.

Persistent economic success in Luxembourg can only be gained through faith in education and by equipping young fresh minds with the necessary skills for a successful career: high expertise in a specific subject preferably in one of the STEM disciplines, self-mastery and willingness for life-long learning, abstract and creative thinking, and most importantly, every aspect of entrepreneurship and business skills which ultimately turn innovative ideas into marketable goods.

The digital revolution likewise called for a revolution in the 'classrooms' with implications for new curricula, new organization, new teaching and new student assessment. In order to raise intellectual elite for the national and international technology-driven job-market, the ministry of education brought together teachers, academics, scientists and representatives from business and industry to discuss and finally implement E-MoST (Figure 6), a radical new education system influenced by U.S. and Asian education mindset. Due to the high workload of parents and occupation even during leisure time a large share of responsibility for children is outsourced to school environment and teachers. There are strong links between Luxembourg's education system and those of the other members of the new European coalition, with partners sharing best practice and skills-based curricula.

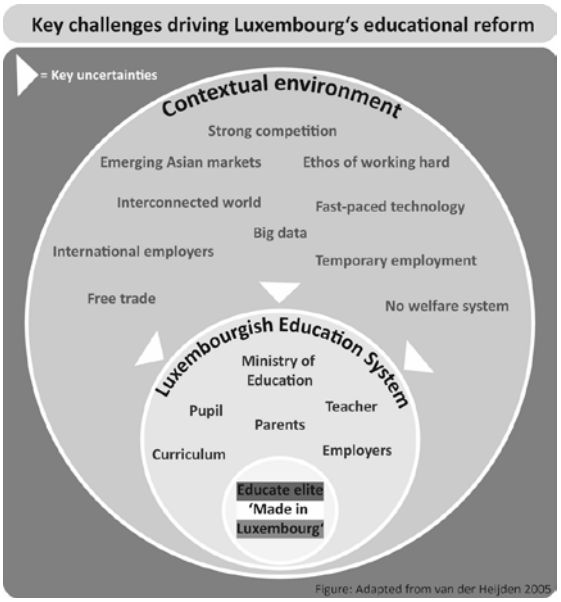

Figure 5: Key challenges driving Luxembourg's educational reform. Contextual environment

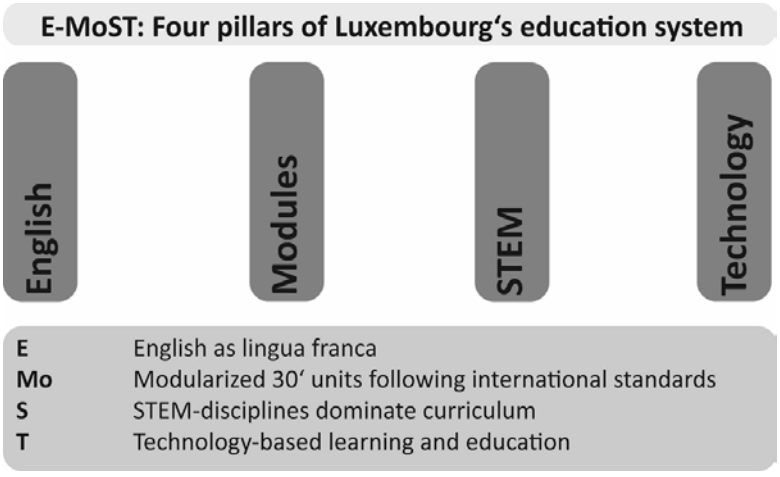

Figure 6: E-MoST, Luxembourg's campaign for changing education.

III.1 Governance and finance of the school system

Luxembourg's school system is centralized both in terms of power and location. The Ministry of Education develops a nation-wide binding curriculum for the 50 lycées and XX primary schools in Luxembourg. When Luxembourg's rural regions became more and more extinct schools and even well-reputed lycées were shut and relocated in one of the tripole cities. Tasks of the national Ministry of Education comprise the development and implementation of the curriculum, to liaise with international educational authorities and experts and to evaluate and assess schools and teachers.

Assessment in 2030 is crucial because payment and funding of teachers and schools, respectively, is performance-based. In the interconnected world and with availability of big data assessment is easier and more transparent than two decades ago. Schools, similar to individuals, have a relative transparent portfolio in the web on which quality and ranking of a school can be checked. On the basis of performance data of teachers and pupils indicators and parameters are calculated which give a detailed and objective picture of how a school is equipped with knowledge and expertise, both on the teachers and pupil side. Finally schools receive an index according to which they are ranked on a national and international register. High ranked schools get financial bonuses as rewards for their success and incentive to maintain quality whereas lower ranked schools receive earmarked funds to improve quality in the respective fields.

The education system has developed close ties with the local innovation-driven economy. This is of mutual benefit as students become familiar with the latest technologies and the private sector has the chance to select talents and recruit its workforce. Companies send employees as 'teachers from real world' so that students experience realities through their genuine perspectives. CEOs, Heads of companies' RDI departments and public researchers are in the advisory board of the Ministry of Education and were involved in re-shaping Luxembourg's education system. Companies are co-funding university and other public research institutes. Those are thereby technologically enabled to perform outsourced research tasks for the private sector and there is an easy switch possible for scientist from public to private employers and vice versa.

The funding system of schools has fundamentally changed. The state invested heavily in restructuring Luxembourg's education in order to educate elite equipped with the required skills and expertise to serve the national job-market and to decrease the high number of externally recruited experts. As of 2028 schools are co-funded by third parties with the state being in the position to finance not more than payroll and maintenance of basic equipment. Third parties such as parents, companies and alumni finance up to 30% of the needs. This allows schools to make necessary investments, modernize equipment and choose the most able pupils. However, there is strong competition between schools for funding opportunities. Schools are forced to educate successful candidates for the job-market who as alumni will later on support their alma mater.

Companies award scholarships to children who are talented and show a disciplined work attitude. They establish departments for student relationships and take a mentoring role for the pupils supported. Specific curricula developed in collaboration with school teachers equip awarded children with the needed skills and knowledge. Companies get tailor-made future employees and children and their parents benefit from the perspective of a safe position in the future. Investment in education pays off, financially for the companies, intellectually for the students and economically for the society.

III.2 Curriculum

The multi-lingual Luxembourgish education system of the earlier decades with three different languages of instruction could not be sustained. Children learn English as first and French as second language. Full proficiency in English prepares children well to sign in for jobs on the international labour-market and parents can easily relocate to any country with a similar education system, if their own job situation demands for it. Children will face no language-barriers and are used to methods of

instruction. For those children with a specific talent in language acquisition, as revealed in specific tests, instruction in additional languages such as Chinese are offered.

Science, technology, engineering and mathematics (STEM) related skills are not only almost a guarantee to find a job in 2030. STEM workers are also driving the ongoing technological revolution by generating new ideas, new companies and new industries which enabled emergence of new economic leaders in China and India. Consequently STEM-related expertise and talent is needed to compete globally. Not only did main shapers of Luxembourg's educational reform emphasize the need for a schedule based on teaching science and technology, standards especially in mathematics and science were set high, demanding a great deal of ambition and diligence from pupils to reach these learning targets.

In the course of Luxembourg's big education reform language teaching is completely integrated in the STEM disciplines as scientific studies revealed that multilingual children face greater challenges of grasping and solving complex mathematic problems[18]. Another route to large-scale STEM teaching is through video games pupils are playing during their breaks in school. This new path was passionately debated among teachers. However sophisticated learning content ranging from geology over cell biology to algebra and up to 40% positive learning[19] finally convinced most critics to follow this new path. Moreover poor learners and pupils with less talent in STEM fields are reached through this approach.

Luxembourg, with regained financial stability, is in the fortunate position to provide a certain professional perspective even to less skilled pupils and those who fail to obtain university entry degree and thus cannot compete on the internationalized job market. They fill positions with a benefit for the public welfare or they are employed in the public sector.

III.3 Learning, teaching and teaching profession

Technology is found everywhere and therefore logic thinking and handling of technological devices is integrated into early stages of education. Most mothers resume work shortly after birth under full-time conditions and most children at the age of one year attend 'baby class centres'. In these centres children are supervised and trained by well-educated baby-instructors who adopt latest findings from cognitive research to their day-care programmes.

Neuroscientists from one of Luxembourg's world leading Life Science institutes identified key moments of early childhood cognitive development. At these key time points of child development children are subjected to a specific sequence of visual and tactile trainings which increases neuron branching and development of brain regions for logic thinking – a highly-prized skill in the world of 2030.

During their first three years in baby training centres, children are introduced to the technological world. Children choose their daily meals on touch screens, only if a nutritious well-balanced set of components is assembled a ringtone gives positive feedback and the order is processed. Small children wear wristbands, a lean version of a smart watch, but similarly connected to SMART-i. Parents are up-dated in real-time via SMART-i, e.g. at work, about main physical body parameters, what their child eats, when it sleeps, how well it participates and engages in learning etc. Parents value the opportunity of their children being raised in such inspirational environments according latest educative standards and regard high fees as strategic investments into their child's (professional) future.

Education still takes place in brick-and-mortar schools, but not in traditional classrooms and in age-based classes, but stage-based in classroom Teachers do not wipe off chalk sticking at their hands from writing on the blackboard and children do not take out workbooks and pencils from their schoolbags, in 2030 smart boards and smart desks[20] or ICT placemats have taken over. Walls are covered with screens and hologram projectors. Omnipresent technology in private life and at school prepares children to cope with technology in their future working environment.

[18] Xi Chen and Li Yeping, 2008, Research in brief: Language Proficiency and Mathematics Learning. School Science and Mathematics, 108, 90-93.
[19] Merrilea J. Mayo, 2009, Video Games: A Route to Large-Scale STEM Education? Science, 323, pp.79-82.
[20] http://www.smarttech.com/smartboard

Children of same age are not necessarily taught together in one class, but children attend courses that match their individual stage of development. Children might spend every educative unit (lecture, training, interactive game etc.) with different children of different ages. Thus, socializing does not occur within a class of children who spend one or several school years together. Moreover, too close affiliations with other children are not encouraged because children need to be prepared for their future rapidly changing working lives. As adults they will have to change jobs and hometowns regularly and therefore train adaptability and flexibility.

A few schools setup classrooms equipped with technologies to capture biometric data from children. In these experimental classrooms cameras, such as those developed by 'EngageSense'[21], track students' eye movements, conversations and smiles. Smart watches are equipped with sensors which send a small current across the skin and then measure subtle changes in electrical charges as the sympathetic nervous system responds to stimuli[22]. Specific software processes the raw visual and audio data to give teachers detailed information on students' actions. Teachers will then be advised on how to better engage students and how to improve classroom learning.

Novel telepresence and surveillance technologies enable completely new classroom settings in which children follow lessons broadcasted from around the world without presence of a physical teacher. With help of digital technology in the biometric classroom personalized data can be collected during the learning process and deliver prompt feedback. Teacher or digital buddy can address children and call back their attention immediately or forward a personalized interactive learning game to the child's digital placemat if parameters indicate that the child is not able to follow the present task.

A 360-degree feedback is standard, meaning that teachers assess their children and vice-versa. Teachers are evaluated for their expertise in a specific subject and how they convey and share this information. Data retrieved from the biometric classroom can tell precisely how well the class and each single child followed the lesson and how well they participated. Cumulative participation curves of the class as well as curves of individual students help tracking how well teacher attract the children's attention for a subject. The electrophysiological data from children will tell how well information is 'absorbed'.

Besides inferring a teacher's quality directly through learning output of his/her pupils, teacher performance is also assessed indirectly by the number of clicks on his/her SMART-i profile. Pupils need to access a teacher's profile to register for a lecture attended at school or via e-presence, to watch a previously held lesson stored on the web, to access learning material and to hand-in course-work. Frequently 'booked' teachers and teachers whose learning material is highly accessed are not only ranked high in the teacher quality statistics but will be paid accordingly and stay competitive on the job market. This puts a lot of pressure on teachers who constantly have to update their teaching and learning materials.

Children's performance is no longer assessed by marks for certain subjects. New technologies, such as SMART-i, allow teachers and future employers to access performance data and retrieve specific indicators and parameters. They give a detailed and complex picture of core skills and qualifications for 2030's world: intellectual capacity, ability for abstract and systematic thinking, self-esteem, persistence, discipline, absorbance of new information and the ability to work individually as well as in a team. Development curves for specific skills illustrate at which stage a child is, how long it took him/her to reach the stage, how different methods of instruction contributed to this level of development and what level might be reached from anticipating a child's personal skills.

Values have changed in 2030 but value education is more important than ever. Altruism and social and environmental awareness were highly credited values in 2010 but became less important whereas principles such as discipline, self-fulfilment and academic excellence, technological innovativeness

[21] EngageSense: http://labs.sensorstar.com/
[22] Affectiva Inc. :http://articles.chicagotribune.com/2012-06-12/news/sns-rt-us-usa-education-gatesbre85c018-20120612_1_gates-foundation-veteran-english-teacher-teachers-feedback

and financial acumen play a major role. Incorporation of these values can guarantee professional success and since full-time working parents do not have time to do so, these teachers are in the responsible position to convey values.

Cognitive scientists have come to demonstrate how humans learn best in situations that are authentic. Online tools such as didactic games and 'Multi-User Virtual Environment'[23] simulate real world and train problem solving skills. Moreover, such approaches portals render teaching entertaining and children started to see science as more accessible and even fun.

Educating children in 2030 is a challenging profession. Besides struggling in a highly competitive working environment and facing (digital) revolution in their class rooms teachers have to fulfil a plethora of roles and duties as learning, assessment and monitoring specialists, mentors and conveyors of value. After Luxembourg's 'Big Reform' teachers are no longer civil servants. They lost their privileges (e.g. three months of vacation, social security and high wages) and are hired temporarily for four years. Extension of contracts depends on their teaching success and payment is according their rank in the 'teacher quality ranking'. Thus, teachers are confronted with the same stressors as everybody else in working life, which makes them grasping key educational issues more intuitively and enables them to adequately prepare children for the world outside. Since teachers are no longer civil servants the recruitment process has changed. Teachers' profiles and CVs are accessible via SMART-i and thus, school directors can easily search and identify the most adequate person for filling a position.

The 'Institute for Mind, Brain and Learning' has been founded under the aegis of the university to train educators and to diversify Luxembourg's academic sector. The institute offers courses and trainings to teachers held by specialists from different kind of sectors (research, private sector, craftsmen etc.) and thereby allows for continuing education. These courses are highly appreciated as they ensure job safety and at the same time equip teachers with up-to-date knowledge. This means that teachers do not stick to outdated teaching methods but that they constantly adapt to and incorporate novel teaching techniques. Instruction is becoming more individualized as teachers learn how to meet the needs of a broader spectrum of individual differences through recognizing different ways of learning or different intelligences[24]. For decades it was enough for educators to be the passers-on of the content and skills of yesterday, whereas in 2030 they have to anticipate the demands of tomorrow. In addition to having degrees in specific subjects, their training includes studies in the neurosciences, human development, technological progress and the most advanced educational strategies from around the world taught in courses at Luxembourg's 'Institute for Mind, Brain and Learning'.

Methods of instruction are very diverse with emphasize on technology-assisted education and 'self-teaching' as preparation for lifelong learning attitude. Pupils attend lectures with teachers being present physically or virtually, follow online-classes, participate in online games and discussion forums and they are involved in long-term projects in collaboration with research institutes and local industry. Sessions last 30 minute since findings from brain research identified this as an ideal time unit for most efficient knowledge uptake. Schools all over the globe adapted to these 30 minute units and have synchronized curricula which allow children to 'attend' classes worldwide online.

In the early years of the digital revolution teachers saw themselves as 'digital immigrants' and their pupils as 'digital natives'[25]. A competitive job market and Luxembourg's educational reform forced teachers to become acquainted with digital technologies. Yesterday's digital natives are nowadays teachers, who apply their digital expertise in how they instruct their pupils and use a wide array of instructional tools. Digital native teachers annotate their slides with digital ink displayed simultaneously on smart boards and pupils' smart desks[26]. When slides containing exercises are presented, students

[23] http://rivercity.activeworlds.com/rivercityproject/index.html
[24] Dee Dickinson: http://education.jhu.edu/PD/newhorizons/future/articles/imagine/
[25] Marc Prensky: http://marcprensky.com/ and http://en.wikipedia.org/wiki/Marc_Prensky; inventor of the terms "digital immigrants" and "digital native".
[26] Richard J. Anderson, Crystal Hoyer, Steven A. Wolfman, 2004, A Study of Digital Ink in Lecture Presentation, Proceedings of the 2004 Conference on Human Factors in Computing Systems, CHI 2004, Vienna, Austria, April 24 -29.
http://webcache.googleusercontent.com/search?q=cache:JX363Cv5W0cJ:www-devel.cs.ubc.ca/~wolf/papers/chi-2004-inkstudy.pdf+&cd=2&hl=de&ct=clnk&gl=lu&client=firefox-a

work through them and anonymously submit their work wirelessly. The system software then uses artificial intelligence techniques to automatically interpret and aggregate the student responses, enabling instructors to view a summary of in-class student work in real time. With such information, instructors can address student misunderstandings and adjust their lessons dynamically[27].

Outlook

This scenario, characterized by strong competition, technological innovation and entrepreneurship, lifelong learning and the absence of public welfare systems, appears to be rather radical in a way that the individual almost disappears in the crowd. It is becoming an invisible part of a strong engine and it appears worthwhile to further analyse the social and psychological implications on individual and societal level of such a scenario.

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[27] http://projects.csail.mit.edu/clp/about/