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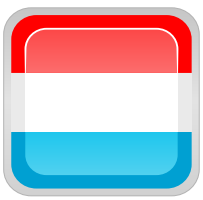
VOCATIONAL EDUCATION AND TRAINING FOR THE FUTURE OF WORK

LUXEMBOURG



CEDEFOP REFERNET THEMATIC PERSPECTIVES

Vocational education and training for the future of work: Luxembourg

Policy strategies and initiatives to prepare vocational education and training (VET) systems for digitalisation and future of work technologies

infpc
institut national
pour le développement
de la formation
professionnelle continue

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The thematic perspectives series complements the general information on vocational education and training (VET) systems provided in VET in Europe database. The themes presented in the series feature high on the European agenda.

Thematic perspectives provide national overviews of specific themes in a common format and offer comparative dimension across the EU Member States, Iceland and Norway. They are available at:
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CHAPTER 1.

Introduction – Impact of digitalisation in Luxembourg

Digital Luxembourg, founded in 2014, is a multidisciplinary government initiative working with public, private and academic players to harness digitalisation for positive transformation. To achieve this goal, it approaches digitalisation holistically, focusing on strengthening and future-proofing five key areas: skills, policy, infrastructure, ecosystem and government. Executing the Luxembourg government's digitalisation strategy, Digital Luxembourg enables new projects, supports existing ones & boosts the visibility of nationwide efforts.

The Education Ministry strongly contributes to this national initiative with a set of projects and initiatives firstly presented in the Digital Strategy (4) Education (Chapter 2) and now in the new strategy « Simply digital - future competences for strong children » (« einfach digital - Zukunftskompetenze fir staark Kanner »).

Looking at 2019 DESI index (the European Commission Digital Economy and Society Index), Luxembourg ranks 6th out of the 28 EU Member States. The in-depth analysis of the Human capital dimension (Based on 2017 data) reveals that Luxembourg ranks third, scoring well above the EU average. Luxembourg ranked first in all three digital literacy indicators (share of 16-74-year-olds having at least basic digital skills, above basic digital skills and at least basic software skills). Luxembourg also performs comparatively well in advanced digital skills, with 5.8% of graduates holding ICT degrees (in 2018). Furthermore, the share of ICT specialist as a percentage of total employment has increased to 5%, well above the EU average of 3.7%.

It is important for Luxembourg to develop a national pool of skills and human resources adapted to the diversity of trades and technologies of the digital age.

National Education has a duty to equip young people with the skills and knowledge they will need to adapt to our changing world.

From artificial intelligence to machine learning, new technology has become a fixture in headlines that predict the future of practically every industry. It is thus also important at national level to support the working population in acquiring new competences and upgrading skills to appropriate themselves and master new technologies.

A digital strategy implies different levels of implementation. The objective of the article is to focus on national programmes and initiatives using or promoting i.4.0 technologies (such as robotic, 3D printing, Internet of things, Artificial intelligence methods) at IVET and CVET level.

During the Federation of Luxembourgish Industrials 2019 New Year reception, the Luxembourgish prime Minister stated that if Luxembourg wants to continue to position itself in the digital world, artificial intelligence appears as a new pillar to build. He also added: 'We will federate the ecosystem of skills, for example by supporting courses in the field, from an upskilling perspective, but also research. And we will showcase those who are already champions in artificial intelligence, to attract those who need these skills…'

When it entered into force the new Governmental programme ([1]) stated that Luxembourg will 'develop a national strategy in the field of artificial intelligence, with the aim of becoming a European pioneer in this technology of the future'. A new Ministry of Digitalisation was created, which mission 'is to sustain the general technological development in the areas important to Luxembourg economy and to develop new strategies for Luxembourg to move forward, but also to improve the daily lives and the various administrative processes. Much of the work of the Ministry is focused on making people's lives easier'.

In January 2019, the Prime Minister announced a national strategy on artificial intelligence and stated that if Luxembourg wants to continue positioning itself in the digital world, artificial intelligence appears as a new pillar to build. In the frame of this strategy Luxembourg wants to federate the ecosystem of skills, for example by supporting courses in the field, from an up-skilling perspective, but also research. And wants to showcase those who are already champions in artificial intelligence, to attract those who need these skills. In May 2019, the Government presented a strategic vision on AI, which is described in the last part of the article.

([1]) https://gouvernement.lu/dam-assets/fr/publications/accord-coalition/2018-2023/Declaration-sur-le-programme-gouvernemental-2018-2023-version-FR.pdf

Box 1. Existing digital tools

Luxembourg already implemented various projects and digital tools addressed to learners and teachers such as:

(a) BEE SECURE, a programme which aim is to promote a safer use of ICT through regular information and advices to citizen (https://www.bee-secure.lu/);

(b) Schouldoheem.lu, a Web portal addressed to students, parents and teachers which is a large directory of existing learning resources for primary, secondary and VET education;

(c) MathemaTIC, a digital learning tool for mathematics for Cycle 4 of initial education (http://mathematic.lu);

(d) one2one, the network of schools and teachers exchanging pedagogical experiences using tablets in their daily teaching;

(e) Medienkompass, the adaptation of the DigComp, the European digital literacy framework, with 16 competences in the large to promote at any level of education (http://www.edumedia.lu/) and the overall strategy to promote media literacy on a broader range;

(f) Coding initiatives emerge especially in primary school with new curricula to promote computational think with analog and digital tools. In secondary education, a new course 'computer-science' is planned, focusing on coding and other aspects of digital literacy.

(g) Digital Classroom Lëtzebuerg (DCL), a technical and technological skills development program in two parts:
- the introduction of 'Office 365 for Education', which will enable free access to a modern digital production and collaboration environment to 12 000 primary and secondary teachers, 45 000 secondary school learners and 5 000 administrative workers;
- Innovative Schools, a project on the use of digital tablets in the classroom and the promotion of new learning strategies that they allow.

(h) several digital didactic supports dedicated to Luxembourg General Culture:
- Lucilin: an interactive application developed on the model of an adventure game for learners in cycles 3 and 4 of the primary school to discover the history, culture and geography of Luxembourg;
- Eis gebaute Welt – vu gëschter, haut et muer (Our built World - from yesterday, today and tomorrow) : a set of educational sheets and a 'backpack of activities' addressed to learners in primary school to discover the built environment and architectural heritage of their municipality;
- kulturgeschicht.lu: a didactic website that allows secondary school learners and the general public to discover the cultural history of Luxembourg through several themes (history, theater, media, language situation, etc.) (https://www.kulturgeschicht.lu).

CHAPTER 2.

VET policy strategy to adapt to digitalisation

In 2015, the Digital (4) Education strategy was developed based on five dimensions that are broken down into specific projects, with a major focus on IT infrastructure and equipment. Each project provides school or extracurricular actors with the necessary tools (software, hardware, pedagogical resources, pedagogical scenarios, learning places, etc.) to create learning situations that promote the development of skills for the 21st century.

(a) *The citizen dimension - digital citizen*: introduction in schools of key computer applications, essential in the learners' future life as a citizen: administrative procedures, communication with authorities, e-banking. Raising awareness of children and young people on issues related to the use of personal data and related controversies.

(b) *The ethical and social dimension: digital peer*. The use by children and young people of ICT in a safer and more responsible way, including security on the Internet (protection of personal data, passwords etc.), moral harassment in social media (cyber-mobbing, sexting, etc.), image rights, etc.

(c) *The dimension of support for learning: digital learner*. Creation of learning situations (for teachers and learners) that promote the development of 21st century skills, appropriate resources (learning tools, software, multimedia resources, etc.).

(d) *The productive and operative dimension: digital worker*. Development of learners' skills necessary to manipulate basic technological tools (preferably in a cloud environment) of their future professional life.

(e) *The creative or innovative dimension: digital entrepreneur*. In several sites, creation of so-called 'MakerSpace' to stimulate talent, encourage young people to become interested in technological tools and thus help to train future specialists in the digital economy (see page 18).

On February 6th, 2020, the Ministry of Education announced a new strategy for digital education from primary school to secondary technical and classical education. «Simply digital - future competences for strong children» («einfach digital - Zukunftskompetenze fir staark Kanner») aiming at strengthening the competences of the 21st century by a set of measures with a stronger focus on the promotion of computational thinking and coding:

Anticipating the increasing demand for digital skills in professional and private life, the strategy for digital education aims to foster not only computational skills. It

is based on 5 uniquely human competences (5 C): **C**ritical Thinking, **C**reativity, **C**ommunication, **C**ooperation, **C**oding.

Critical Thinking and **C**reativity are skills essential to innovation that can be learned and taught in any class. Critical thinking allows to search, analyse, and synthetize information by selecting reliable sources in the overabundance of available information. Creativity describes the ability to imagine, invent, build, implement a new concept, a new object or discover an original solution to a problem

Communication and **C**ollaboration are fundamental life skills that learners can acquire from their daily school experiences, they shape their ability to live, to connect with others and to work effectively in their future professional life. Communication includes the capacity to clearly express and share idea, opinions or instructions in oral or by writing in using the appropriate form (netiquette). Collaboration is the capacity of learners to learn together, cooperate and share knowledge using digital technologies.

Coding is part of the essential skills and will be introduced in Luxembourgish school since September 2020 (See 4.1.1).

The measures taken are part of the 'Media compass' ('Medienkompass'), a framework of reference providing guidelines to schoolteachers that has been issued by the Ministry in March 2020. Finally, in the frame of the initiative 'Simply Digital' a campaign on media addressed to parents is launched subsequently.

The Education ministry launched the Future Hub ([2]) label to promote high schools that are open to technology and innovative learning in science, technology, engineering and mathematics fields. These secondary schools prepare young people for the diversity of jobs in the ICT sector, thanks to adapted teaching methods. The Future Hub schools integrates of a variety of training and specialisation courses with technological characteristics in their school offer. In this schools, an emphasis is placed on the integration of technologies in learning methods while promoting students' creativity and sense of initiative. Three secondary schools have already received the Future Hub label: the Lycée des Arts et Métiers in Luxembourg (LAM), the Technical secondary School of Esch-sur-Alzette (LTE) and the Edward Steichen secondary School in Clervaux (LESC).

In general secondary education a new section I, IT and communication, welcomed its first students in September 2017-2018 at the Lycée des Arts et Métiers in Luxembourg and at the Technical Secondary School in Esch-sur-Alzette. Section I aims to train digital leaders and IT professionals, able to master the creation and application of new technologies and opens access to higher education especially in the fields of computer science and technology.

([2]) https://portal.education.lu/futurehub/

The development and periodic revision of programmes are ensured by curricular teams and National vocational commissions of vocational training which both include representative for each trade and profession concerned, this organisation is a guarantee for taking into account the needs and expectation of labour market in terms of the learning and use of new technologies.

Mid-2009, Luxembourg gave a new governance structure to its National Coalition for Digital Skills and Jobs ([3]).

The Coalition's governance body is now formed by the Digital Luxembourg initiative in the lead in close partnership with the Chamber of Commerce and the Chamber of Skilled Trades and Crafts (Chambre des Métiers); and coordinated by the WIDE association.

This Digital Coalition is an exchange platform for all private and public stakeholders involved in the promotion of digital skills. The Coalition allows to focus on matchmaking between project needs and help from the private sector. Regular members meetings enhance exchange of best practice and networking.

Thus, the Digital Skills and Jobs Coalition is helping to scale digital training offers for jobseekers, supporting teachers with IT volunteers within coding workshops in primary schools, or providing cutting-edge training for ICT specialists.

([3]) www.digitalcoalition.lu

CHAPTER 3.

VET 4.0 initiatives and programmes

3.1. Strengthening IT-based learning

3.1.1. Introduction of coding in pre-school and primary education

In its press release of September 2019, the Ministry of Education underlines the importance of the development of coding competencies and of computational thinking, as an inescapable mission of the 21st century school. More and more jobs are opening-up for advanced digital skills profiles. Therefore, the Ministry of Education's new education strategy aims to introduce coding in school curricula and to focus on computational thinking.

The implementation of the coding program is part of the media education and literacy promoted by the ministry since 2010 in cooperation with the National Institute for Research in Pedagogical Innovation (SCRIPT). The release of the media compass (Medienkompass) in 2019 had been an important milestone in this regard; children should be able to critically handle analog as well as digital media. However, using media is not enough. Applying computational thinking means that children will learn how digital devices are thinking and acting, often automatically by using algorithms. This knowledge will support young people to become active co-constructors of their (digital) environment.

Aiming to foster the development of these competencies from an early age, coding and computational thinking will be introduced in the context of mathematics in the last two years of the six-year primary education from 2020/21. Both skills will be first evaluated in 2022 as part of the common tests (épreuves communes) in the final year of the primary school education (C4.2). More information on the implementation of the coding program are presented on the new webpage www.educoding.lu. The initial coding concept with its ideas has been tested in 15 selected primary schools in 2018-19 lead by the SCRIPT (National Institute for Research in Pedagogical Innovation). This pilot project aimed to test interactive intelligent blocks designed for educational purposes, that combined characteristics of various electronic devices (Ozobot, Kniwwelino, Lux-Robo Modikit) combined with unplugged exercises. The evaluation of this pilot period had been crucial for the qualitative development of the program. Its process has been filmed and is now accessible at the mentioned webpage www.educoding.lu.

During the EU-Code week in November 2019 children from more than 30 classes were already applying their skills in various workshops. They were coached together with external coding partners and their teachers.

Implementing the programme ‘simply coding’ requires a good preparation of the teachers. Together with the national institute for the teachers’ training (IFEN) several workshops and trainings will be offered continuously on different levels and for different tools. Together with external coding partners and the I-CN (*instituteurs en compétences numériques*), teachers, specialized in digital competencies supporting primary schools and their staff, a strong scaffolding will be set in place.

From 2021/22, coding and computational thinking will be introduced as a transversal matter throughout all branches of elementary and primary education from the beginning of compulsory schooling at age 4. Children as this age will approach coding by using unplugged exercises. These are learning methods, including games and riddles, supporting problem-based thinking, and informatic thinking without digital devices. Step by step, hence forward the children will use small robots they can program themselves with simple commands. The complexity will be increased by age and class.

In 2019-20, the National Institute for Research in Pedagogical Innovation (SCRIPT), together with the governmental initiative Digital Luxembourg, supports a variety of coding initiatives, like for example CODESTART: 10-day developer training for students who have completed their final high-school exams or for young people over 17 years old; held during Easter & summer holidays

3.1.2. New technician programmes

A new technician programme (DT) in Smart Technologies has been introduced in 2019-20 in five secondary schools. It takes account of the technological evolutions in the domains of electronics and informatics (robotics, Smart and Green Energy, Smart Home, E-mobility, Internet of Things (IoT), communication networks etc. ([4]) The number of registered students doubled already the first year the new programme started.

A second new technician programme is Smart Materials, which focuses on the design of products based on synthetic materials. A large part of this training also covers sustainability and circular economy in terms of recycling material that was also used in a former production process. This new programme will be launched in one school in September 2020.

([4]) http://www.men.public.lu/fr/actualites/articles/communiques-conference-presse/2019/09/13-rentree/index.html

3.1.3. New higher technician programmes [brevet de technicien supérieur] (BTS) gaming and internet of things (IoT)

For more than 20 years, the Lycée des Arts et Métiers (LAM), the oldest public technical school in the country, has been awarding numerous diplomas including higher technician diploma [Brevets de technicien supérieur] (BTS). Since September 2018, three new higher technician programmes have been launched: 'internet of things' (IoT), 'game art and game design' (AG) and 'game programming and game design' (GP).

The creation of these three new BTS is part of an approach which consists into opening to technologies and innovative learning of science, especially computer science. It also meets the needs expressed by companies. Initiated over a year ago, the evaluation of the need for such diplomas was then based on a preliminary market study that only confirmed the validity of the approach.

These programmes have been developed focusing on two aspects: education, to create a pool of qualified people, and economics, to set up an environment likely to attract a large number of international firms to Luxembourg. Collaboration with actors in the fields allow to develop and adapt a leading-edge school offer.

A partnership has also been formed with Isart Digital, the international college of video game & animation 3D-FX, based in Montreal and Paris (with a partnership in Tokyo).

In the process of validating these BTS courses, the contribution of Luxembourg Creative Industries Cluster ([5]) managed by Luxinnovation, is essential, especially as a facilitator for creating contacts and networking. The Luxembourg ICT Cluster, of which the Lycée des Arts et Métiers (LAM) is part, also helps to develop a relationship with national and international companies.

As for the more 'technological' component, it fits perfectly into the government strategy of a data-driven economy. With this BTS diploma, graduates will be immediately employable in the industry and, in a broader sense, in all 'smart' areas that are currently being developed.

Given the wealth of skills required, the two BTS 'gaming' courses at the Lycée des Arts et Métiers (LAM) will evolve in a way that they complement one another perfectly: the BTS 'game art and game design' will focus on design, story-telling, visual and textual creation of a game, with a small programming component.

As for the BTS IoT, it will allow a global coverage of processes, from the original idea to the production of a prototype, integrating all aspects of technology and aesthetics. These new courses are attended by a limited number of learners, to ensure the most personalised education possible. Each learner also

([5]) https://www.luxinnovation.lu/fr/cluster/luxembourg-creative-industries-cluster-2/

participates, as part of his training or organise several events in direct line with their activity. The creation of a Global Game Jam that will take place at Lycée des Arts et Métiers is planned.

3.1.3.1. *BTS internet of things (IoT)*

a) *Overview*

This two-year higher education course was developed in consultation with the professional sector concerned, in order to guarantee a perfect match between the professional profile and the content of the training.

Organised in semesters and modules with ECTS credits, the BTS curriculum includes a period of internship in a professional environment. The training was accredited on June 26, 2018 by an external accreditation committee and started in September 2018.

b) *Learning outcomes*

Graduated from BTS internet of things, will be able to work as IoT product designer, IoT manager, IoT system developer, IoT system maintainer or IoT system tester.

c) *Course content and programme*

The curriculum has been developed to focus not only on the transmission and acquisition of knowledge, but also on the development of personal and methodological skills. Course are organised in a way that learners are involved in their training.

The practical cases link to the theoretical training by presenting real situations with all the underlying problems. The techniques taught to solve these situations will serve learners throughout their professional life.

Table 1. Planning of courses BTS IoT

	ECTS per Semestre			
	1	**2**	**3**	**4**
Communication FR, DE, EN	6	6		
Mechanics	5	5		
Industrial Product Design			6	
Code Crunching	3	3	4	
Networks Fundamentals	2	2		
Linux	2			
Data Management		2		
Global security Concept			2	
Electronics Fundamentals	5			
Microcontroller Systems		5		
Sensors Interfaces			3	
Bus Systems			3	

Circuit Design			2	
Creative project	7	7	10	
Real life project				9
Training				20
Visits and Events				1
Total	30	30	30	30

3.1.3.2. *BTS Game art and game design*

a) *Overview*

The game artist has strong 3D and art skills and can design and produce 3D work for a variety of uses including 3D games and animated films. This occupation includes several aspects:

(a) creative work: research, conceptualise and take creative decisions, work with colour, shape and volume to design virtual worlds, their content and their inhabitants;
(b) technical tasks: work with modern, specialised software and create the 2D & 3D assets, levels and characters required to bring digital games to life;
(c) work in teams: the production of games relies on the teamwork of specialised creatives.

b) *Learning outcomes*

The course aims to empower the learners to fulfil job roles such as game artist, character designer, 3D artist, level designer, concept artist, technical artist or interactive media designer.

Dependent of the individual skill level of the person, further studies or independent work in the sector are a possible.

c) *Course content*

(a) visual design techniques: visual design 2D, acting telling;
(b) asset creation: modelling techniques, texturing and materials, character design, animation techniques, modelling for games, analytical and concept drawing, art direction;
(c) game design and level creation: user interface (UI) and user experience (UX), game design and level creation, artistic game prototypes, optimisation techniques for real-time 3D, open world level creation, game culture and history, game engines and scripting;
(d) projects: individual and group projects, events;
(e) project management: agile project management, monetisation, publishing, entrepreneurship, active English;
(f) internship: 6-week internship in a company.

3.1.3.3. *BTS game programming and game design*

a) *Overview*

The BTS game programming and game design is designed to prepare learners for the development of digital games of the ‘serious gaming’ and ‘playful’ types by offering them solid programming bases in various programming languages, in using ‘game design’, ‘level design’ and ergonomics techniques and applying appropriate mathematical and physical rules. The learning experience is organised through lectures, tutorials, self-study, individual projects, group projects, inter-course projects, interdisciplinary projects and seminars. Along with these activities, learners will participate in private and public events to get in touch with national and international professionals.

b) *Learning outcomes*

Graduates of the BTS game programming and game design will be able to create games using ‘game design’ and ‘level design’ techniques based, among other things, on historical developments; realise large-scale computer applications using advanced programming methodologies; to define, plan and realise the different transmedia aspects of a game; to use different existing game engines for the concrete realisation of applications; to create scenarios of the ‘serious gaming’ and ‘playful’ type games; to use 2D and 3D mathematics to solve graphic problems; plan revenue using different ‘monetisation’ models; to produce graphic productions and simple 2D and 3D animations; perform computer projects independently or in groups; to know and analyse the main activities of a company; to treat and adapt to new subjects autonomously; to communicate in English.

The graduates will be qualified to work individually or as part of a team, within companies or as independent entrepreneurs in the sectors of the production of video games or in the creation of any computer applications. They will also be able to work as technical artist, an intermediary between artists and programmers working on the creation of a video game. Furthermore, the syllabus will enable learners to meet the requirements necessary for academic advancement in the field of computer game creation.

c) *Course content*

(a) design: 2D & 3D modelling, game and level design, user interface (UI) and user experience (UX);
(b) programming: object oriented programming, web and mobile programming, game engines, database fundamentals;
(c) project management: agile project management, monetisation, publishing, entrepreneurship;

(d) internship: 6-week internship in a company.

In order to be admitted into one of the three BTS any student must have passed the admission examination, be ranked among the first 12 candidates, have confirmed his/her registration for the registration deadline by completing the registration form and have paid the required registration fees. The student admitted to the admission examination who does not fulfil their obligation of the registration before the deadline, automatically gives way to the next candidate on the waiting list.

3.2. Investing in school IT infrastructure

3.2.1. Investment in IT equipment of secondary schools

Secondary schools are supplied with IT hardware according to their educational purposes. The programme One2One, aiming at supplying every learner in secondary education with a tablet or portable PC will be continued. The device is provided by annual rental at modest cost. In September 2019, 32 Secondary schools (Lycées) participate in the project with a total of 12.140 tablet PCs ([6]).

3.2.2. Luxembourg TECH SCHOOL

The Luxembourg Tech School ([7]) A.s.b.l (LTS) is a new extracurricular school to support the development of future Digital Leaders. It is aimed at 15-19 years old learners who are passionate about the digital environment and eager to learn and apply technology in a real business context. The first pilot school started in September 2016 with about 30 learners from secondary schools at the Geesseknäppchen Campus ([8]). This was an immediate success, so far, the 'Tech School' has been offered in eight secondary schools on three sites (Esch/Alzette, Geesseknäppchen campus and Limpertsberg). It is planned to be extend to new secondary schools. Each year, LTS is coaching more than 120 learners. There are one or two groups at each LTS with max 20 students per group. During the first year, learners follow a business and technology program divided into three blocks. The 3 blocks rotate between schools, each school host one module. They get personalised coaching and work on their own projects, which they showcase at the end of each block. No prerequisites are needed to attend the courses however a competitive selection could take place.

([6]) http://www.men.public.lu/fr/actualites/articles/communiques-conference-presse/2019/09/13-rentree/index.html, p. 15

([7]) http://www.techschool.lu/

([8]) Campus Geesseknäppchen is a campus in Luxembourg City.

Each course is 12 weeks long and focus on one specific business domain. At the end of each course, the learner will have the opportunity to present his project.

The blocks are full of practical examples and exercises. The learners work on their own project. They learn software development, entrepreneurship and increase their presentation skills by multiple factors.

Everything is based on team work around creative and innovative ideas. Ideas come from the learners and his/her team, and a coach guides them along the process.

3.2.2.1. *Learning content*

a) First year (Level 1)

- Game Dev: how to develop video games from idea to mobile or to market, games, business, serious games, sharpen the coding skills, learn game development toolkits, pitch event;
- Big Data: discover machine learning (ML), create models, analyse online reviews, analyse Facebook data, code with Python and ML libraries, learn all about Cloud computing, pitch event;
- FinTech: how financial transactions work, App design and user experience (UX), banking Apps and APIs, Blockchain, crowdfunding, learn security and encryption, pitch event.

Coaches continuously collect student feedback to continuously adjust courses. Considering the positive feedback and questions from learners regarding the follow-up of this first year, the LTS extended the programme with a Level up programme.

b) Level up

- Space resources: learn and understand the basic elements of space mining, motivate space, explorations, sciences and robotics, mission planning & communication, launch platform, landing & return vehicle, autonomous moon mining rover, future asteroid mining ‘rover’ design, special Event;
- A.I. 4 finance: learn and understand applications of artificial intelligence, develop new FinTech concepts, build Chatbot, create an advisor based on deep learning, learn and experiment with fraud detection, go deeper into machine learning techniques, special event (Hackathon).

3.2.2.2. *Examples of projects realised*

Here are some examples of project realised in 2016/17:

- nine fun and serious games developed via open selection process; five under publication;

- eight big data analysis projects via open selection process; from ‘inequality in the world’ to ‘UFO sightings’. The Tech school participants presented their big data analyses at ICT Spring and developed future banking apps during the LHoFT ([9])’s hackathon. In 2017, its video game development competition, held in collaboration with Technoport, proved that it was possible for teams of young people to create professional-quality video games from scratch in a matter of 12 weeks.

End of January 2019, at the 3rd LTS game development pitch competition Luxembourg Tech School learners pitched their games, they demonstrated what is possible to develop in 12 weeks.

([9]) Luxembourg's Fintech Innovation Hub

CHAPTER 4.

VET 4.0 learning practices

4.1. Makerspaces

'BEE CREATIVE' aims on the one hand to motivate children and young people to create using technical tools and new media and on the other hand to promote entrepreneurship. Developed by the National Youth Service (SNJ) and the Department for Coordination of Educational and Technological Research and Innovation of the Education Ministry (SCRIPT) as part of 'Digital Luxembourg', the project culminated in 2015 in the launch of several 'educational makerspaces'. A 'Makerspace' is a place where young people can discover and create their own digital tools. The power of makerspaces stem from their simplicity. In the Makerspace, young people learn that their resourcefulness has no limit, as they apply new media to realise their own digital projects. Equipped with robots, 3D printers & laser cutters, youth come face-to-face with the potential of modern technology.

In 2015/16, six Makerspaces have been put in place. Since then, the marketspace network has expanded and is now as followed:

(a) Base1 – makerspace accessible to groups, classes and individuals from situated in the Forum Geesseknäppchen (a campus in Luxembourg-city);
(b) 20+ makerspaces in secondary schools (Annex 1);
(c) three makerspaces in halfway houses (*maisons relais*) and primary schools;
(d) free Makerspace workshops introduce programming, robotics, 3D printing & divergent thinking, i.e. how to make a robot out of matchsticks or a computer hard drive.

Workshops can be of three forms:

Open space

Individuals between 8 and 25 years old can visit the Makerspace Base 1 during the open space hours and discover the infinite possibilities for their own project. It is also an opportunity to meet other young people and embark on a 'Maker' project together. Open space sessions are always free of charge and are accompanied by experts in the field. Learners can accomplish projects like building their own drone or a robot, programming their own video game or creating their own music.

Workshops to be reserved

For groups with at least five people between 8 and 25 years old, variety of workshops are available on reservation in several languages. There are for all

ages, levels, interests. From robotics, electrotechnical, programming, design to3D printing, they allow to discover the fun approach to new media and digital skills.

Some examples of workshops are

(a) programmatic drawing with a CNC machine: programming, 2D orientation, inspection of G-Code;
(b) 3D printing: discovery of 3D printing and the mechanics of 3D printers;
(c) game-remixing: Scratch is a powerful yet simple coding interface to learn about game design. In this workshop it's utilised to let young makers look behind the curtain of existing games, see the code, the graphics, the sounds and how they were used. In the next step our young game designers try and replace.

Code Club Luxembourg

Code Club Luxembourg is the result of a cooperation of three communities: the Code Club World, the Impactory (a co-working space for social impact) and the web workers of Betacube. Code club also organises 'Coding Goûter'. A Coding Goûter is a multilingual event (EN/FR/DE/LB) where kids aged 6 to 12, accompanied by an adult, get to know computer programming in a fun and playful way.

On the 17th and 18th of December the fifth edition of the 'Makerfest' took place, it is alternately organised by the SNJ and the SCRIPT. More than 30 different New technology and creativity workshops were offered this year for children from the age of 6. Thus, the 'Makerfest' was the ideal meeting place for classes from elementary and secondary schools, for groups from the halfway houses (maisons relais) and the youth houses as well as for families. More than 2 100 visitors attended this event. Various activities were presented ranging from coding to robotics to 3D printing. There were also various presentations and interactive activities on the topics such as 'virtual reality' and 'life in space'.

Makerspace Base 1 is a space equipped with various technical tools and led by a team of five experts in various fields such as electrical engineering, programming and 3D. In 2017, base 1 registered a total of 2 500 participants. Two 'make @ ons' were organised in 2017; during between six to eight hours, the young participants must realise a project group using preselected equipment and electrotechnical components.

4.2. IFSB serious games

The Institute for Construction Training (IFSB) has recently implemented three serious games.

4.2.1. IMSAFE

Learn about safety on the job without putting yourself in danger

Based on the premise that training is one of the keys to reduce accidents on site, the IFSB has developed a range of innovative educational approaches and tools to raise awareness of safety and health at work.

Some risk situations are not transferable to reality. The most telling example is definitely the training to risk for the work-at-height. It is, for example, difficult to simulate in real time a deadly fall or the consequences of hazardous products. It was therefore necessary to find other ways of hitting people's minds in order to reduce the number of accidents. Digital and immersive technologies are particularly useful in these specific cases. The purpose of this game is to allow learners to have a realistic experience immersed in a 3D environment reproducing different common situations on sites where they must act as if they were in a real situation.

4.2.2. IMDRIVE

Learning road safety through virtual immersion

ImDrive is a virtual immersion-based serious game that aims to make construction workers aware of road safety when they travel for work or when they travel from home to work. This educational tool consists of 12 scenarios lasting three to four minutes, which cover the most common risk situations (mobile phone, speed, seatbelt, alcohol, etc.). The user is immersed in the various scenarios using either a virtual immersion helmet and is heading into the 3D environment with a steering wheel and pedal.

4.2.3. IMBUILD

Serious game to promote construction trades among young people

IMBUILD ([10]) is an immersive serious game, in which the player plays the role of a construction worker who must gather the necessary equipment to build his building. It thus has a concrete overview of all the ins and outs of a construction project.

IMBuild is an innovative educational tool designed to awake the interest of younger generations in the construction trades.

([10]) http://www.building-generation.lu/serious-game-imbuild/

4.3. Delta Working group

In January 2019, Luxembourg welcomed the working group ‘Digital education: learning, teaching and assessment’ (DELTA) in order to discuss about the digital game-based learning.

During the first day the Luxembourg Education Ministry presented its main projects such as MathemaTIC and Lucilin (see Box 1).

The second day was dedicated to the visit of the LAM (lycée des arts et métiers) for a presentation of the Higher Technician Diplomas ‘game art and game design’ and ‘game programming’. The students presented their on-going projects.

During the closing conference similar projects in other European countries were presented.

CHAPTER 5.

Adapting to AI and automation

5.1. AI Strategy

At the end of May 2019, the government presented Luxembourg's vision of artificial intelligence (AI) which aims at driving the country's digital transformation forward. The strategy reveals how Luxembourg could reap the benefits of this influential technology while at the same time ensuring protection for fundamental principles regarding ethics and confidentiality.

With the aim of adopting a leading position in the digital world, three ambitions have been defined:

1. Being one of the most advanced digital societies in Europe, if not the world;
2. Focusing on a sustainable economy based on data;
3. Promoting the development of AI by applying a human-centred approach.

To be able to adapt to the rapid changes in the sector, the Government is considering its strategy above all as a ‘political vision’ that can be re-adjusted at any time.

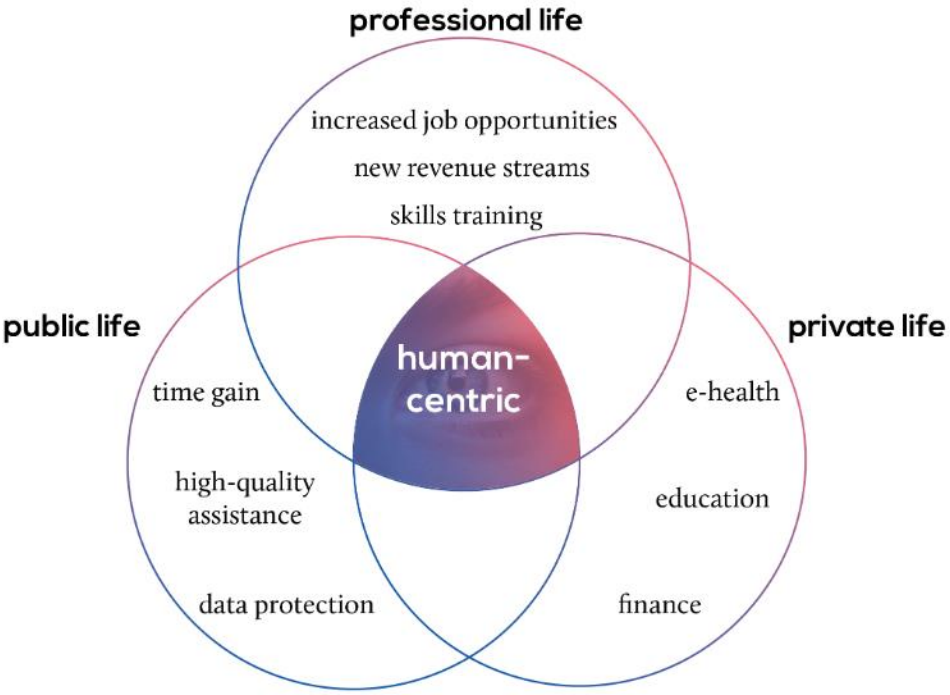
The AI strategic vision is inspired by the « Ethics Guidelines » from the European Commission.

Nowadays, AI is mainly used as complementary technology, e.g. in supporting medical staff, for the execution of dangerous, time-consuming or repetitive work, or for automatic fill-in of extensive administrative forms.

In its strategic vision, Luxembourg considers that like all high potential technologies, the adoption/integration of AI will have a major impact on the society as a whole and will inevitably entail future challenges.

The Luxembourgish Government intends to raise citizens' awareness of AI and help them gain a deeper understanding of it and promote the step to becoming active users of AI products, services and technologies. In its human centred approach, Luxembourg’s strategy encompasses private life, professional life and public life.

Figure 2: Human centred approach to AI



1. Luxembourg as a living laboratory for applied AI: Luxembourg understands the importance of transferring research findings to the real world. In order to benefit of research results, Luxembourg will focus on key actions such as personalised medicine, establishing world-reference testing facilities, Studying the feasibility of regulatory sandboxes to develop frameworks that can support Luxembourg's role as a leading living laboratory, stimulating activities related to applied research.
2. Data – The cornerstone of AI: the strategic AI vision is an opportunity to revisit and scale up the open data policy. As a long-term strategy, Luxembourg will focus on enabling access to high-quality data and interoperable forms for researchers and companies to build and program their AI applications.
3. Ethics, privacy regulation & security: Luxembourg will develop new regulation that can enable a functioning data marketplace and will promote the Ethics Guidelines for Trustworthy AI released by the Commission's High-Level Expert Group on Artificial Intelligence.
4. Boosting investments & developing strategic partnerships: Luxembourg has been investing heavily in international connectivity, ICT infrastructure and innovative projects for the past 15 years, often engaging in strategic

partnerships. On the R&D side, the National Research Fund (FNR) funds ([11]) project collaborations between researchers and companies in Luxembourg, supporting public-private research on topics like advanced robotics, digital manufacturing, improved design tools and enhanced perceptual capabilities in AI systems. Luxembourg will focus on actions that will allow to remain a leader in terms of investment (deploying and promoting HPC initiative, ensuring synergies between new investments in RD and infrastructures related to AI activities)

5. AI for the public sector: investments in AI projects that provide better, cheaper and faster public services have positive impacts on the whole society (businesses as well as citizens).
6. Skills & lifelong learning: The increased use of AI in professional environments requires the anticipation of future skills and, once identified, a strong investment in upskilling programs. Lifelong learning programs will need to be strengthened and specific digital and AI-related training programs will need to be offered to allow firms, employees and the unemployed to successfully adapt to a changing labour market.
7. International cooperation: Luxembourg has a long-standing tradition of actively participating in new EU initiatives and reiterates its commitment to investing in EU AI-related collaborations. Given the increasing importance of the Greater Region (four countries encompassing 11 million inhabitants), key cross-regional initiatives will be launched to solve regional issues, such as employment, mobility and health, through AI collaborations.

In order to support the implementation of the national AI strategy, a Governance mechanism has been put in place. An inter-ministerial coordination group, under the leadership of the prime minister, will regularly assess the strategic vision. In order to feed the Government with expert opinions on current developments, an advisory committee composed of experts from the fields of science, technology, legal matters, social impact, ethics and humanities will advise the Government on the implementation of projects and actions resulting from this AI vision, as well as on the consultation process.

In November 2019, the Government launched a public consultation ‘Residents' perception and expectations towards digitalisation’ ([12]) in order to imply all citizens in the national digital transformation. This consultation reveals that citizens

([11]) During the last five years, the FNR has invested around EUR 200 million in research projects related to big data and AI in domains going form Parkinson disease to stand-alone and intelligent systems.

([12]) https://gouvernement.lu/dam-assets/documents/actualites/2019/11-novembre/TNS-Ilres-rapport-digitalisation.pdf

perceive that digitalisation is an essential feature of the development of the country, and that it has already a major impact on their private and professional life.

5.2. AI training programmes

To build a workforce that can feed AI and strengthen society, Microsoft, along with Devoteam Luxembourg, Digital Luxembourg and the ministry for the Civil Service, partnered to launch Luxembourg's first AI Academy. The initiative will offer three training modules: a business program for public as well as for private decision-makers, a 6 week intensive session for technical professionals and an advanced, 22-week training for data scientists and research engineers.
The business portion helps those in leadership roles master AI in order to implement smart AI strategies in their own organizations.

In 2019 the Luxembourgish Government signed an MoU with NVIDIA, followed by a partnership with Research Centers and Uni.lu for an AI Centre of Research. Researchers and students have free access to NVIDIA training modules and can get practical experience with GPUs in the cloud and can become NVIDIA instructors; thus, being allowed to give deep learning courses to researchers, students, developers and data scientists by themselves

Due to the proximity of the University and the presence of NVIDIA trained instructors, the Centre of competence in Belval was chosen as an NVIDIA distribution partner for courses to industry.

5.3. Digital skills bridge

The digitalisation and automation currently happening across all business sectors in Luxembourg and all over the world, is a sharp change impacting companies, jobs and competencies. The current digital and technological transformation of the market affects all companies and trades, with varying degrees of impact: this may be through the automation of production lines in industry, the introduction of blockchain technologies for the management of fund transfers in the banking sector, or the bank of detail etc.

In May 2018, the Ministry of Labour launched, in cooperation with the Ministry of Economy and the National Employment Services (ADEM), the 'Luxembourg Digital Skills Bridge' programme, a pilot project aimed at employees whose positions are changing or at risk due to the digital transformation. This programme strives to anticipate the impact technological developments will have on the skills of employees and employment in general. It offers employees the opportunity to

invest in new business skills or digital and cross-functional. This preventive approach helps to proactively manage change due to digital transformation and allows both companies and employees to adapt to this new environment.

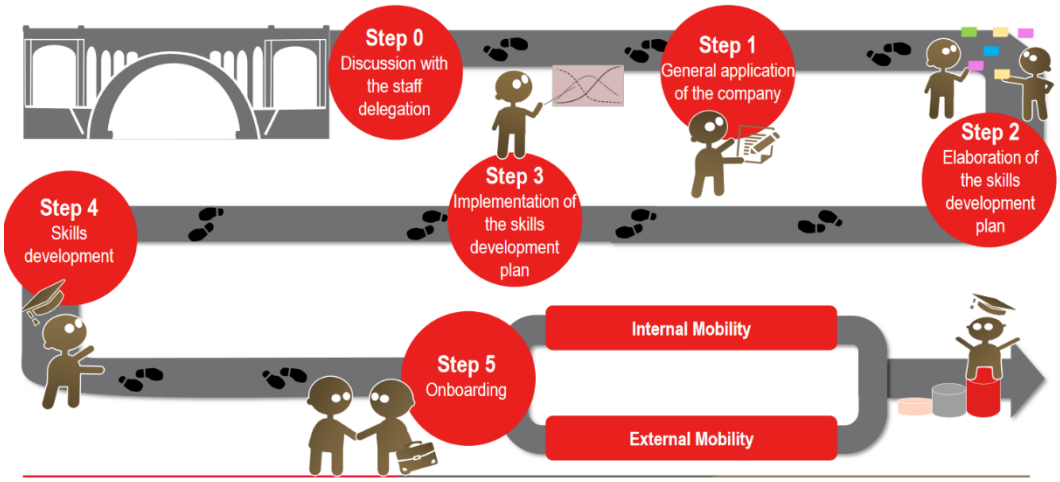
The programme is open to every employee of the participating enterprises. Employees benefit from a skills assessment. An individual advisor supports him/her throughout the process, from the identification of a new position, through accelerated, tailor-made, highly pragmatic training courses until integration into the new function. The employees' career path will be secured, whether he/she remains in the current company or starts a new position in a different company.

Each company will benefit from a technical planning assistance for future human resources and skills management.

The governance of the pilot project is ensured by the 'Comité de conjoncture', which is a tripartite official body that encompasses government and administration representatives, representatives of employer associations and trade unions benefitting from national representation. The 'Comité de conjoncture' is co-chaired by the Ministry of Labour and the Ministry for Economy.

Four training providers have been selected through a call for tenders.

The Skills Bridge process in a nutshell



Source: Luxembourg Digital Skills Bridge – Detailed presentation – 14.5.2018

During the first step of the project, 300 employees from 10 companies took part in the programme. The companies demonstrate their willingness to keep their employees as 95 % of them have chosen trainings that allow them to organise internal mobility.

CHAPTER 6.

Conclusions – Main challenges and outlook

The integration of digital tools in education at the service of new technologies is essential. The development of digital materials, whether digital manuals, web applications or e-learning platforms, is a key objective.

It is necessary to integrate the learning of digital technology and skills across all curricula and develop appropriate teaching methods. Digital skills should become part of a basic education, such as reading, writing and arithmetic.

The future of work entails challenges, particularly regarding digitalisation and integration of AI. Luxembourg has already elaborated a national strategy to adapt to digitalisation and has developed a strategic vision regarding AI. that is designed to evolve in order to be able to adapt to continuous developments in the field of AI. Since 2018, three new higher technician programmes (Brevet de technicien supérieur – BTS) have been launched in order to integrate new technologies and innovative learning of science: BTS 'internet of things' (IoT), BTS 'game art and game design' (AG) and BTS 'game programming and game design' (GP). Extracurricular schools which offer to learners from secondary schools who are passionate about digital technologies an opportunity to learn more and apply them on real projects, were introduced since 2016.

Learning practices in schools but also for workers are adapted to both foster the learners' use of digital tools and improve the teaching practices. A growing number of teachers take part in continuing vocational, e.g. in the use of tablet PCs in teaching. Registrations for courses on tablet-based teaching organised by IFEN (National Institute of Training for the National Education) evolved from 2403 registrations in 2016/17 to a peak of 4318 in 2017/18 and 3008 registrations in 2018/19 ([13]).

The Luxembourg Digital Innovation Hub (L-DIH) has been launched in September 2019 as a result of a partnership between the Ministry of the Economy, FEDIL, Luxinnovation, the Chamber of Commerce, the University of Luxembourg, the Luxembourg Institute of Science and Technology (LIST) and the FNR.

The mission of L-DIH is to actively contribute to digital transformation by supporting companies in their strategic thinking and concrete actions. It will facilitate contacts between companies that need access to digitalisation skills, technologies, services

([13]) http://www.men.public.lu/fr/actualites/articles/questions-parlementaires/2019/11/19-qp-1351/index.html. Last retrieved 29.11.2019.

and support mechanisms on the one hand, and digital technology and service providers that meet the needs of industry, on the other.

Abbreviations and acronyms

AG	Game of art and game design
AI	Artificial Intelligence
BTS	Higher Technician Diploma
CVET	Continuing Vocational Education and training
DCL	Digital classroom Luxembourg
DELTA	Digital Education: Learning, Teaching and Assessment
FNR	National Research Fund
GP	Game programming and game design
HPC	High Performance Computing
ICT	Information Communication Technology
IFSB	The Institute for Construction Training
IoT	Internet of Things
IVET	Initial Vocational Education and training
LAM	Lycée des Arts et Métiers (LAM)
L-DIH	Luxembourg Digital Innovation Hub
LESC	Edward Steichen secondary School in Clervaux
LhoFT	Luxembourg's Fintech Innovation Hub
LTE	Technical secondary School of Esch-sur-Alzette
LTS	Luxembourg Tech Schools
ML	Machine learning
RD	Research and Development
SCRIPT	Department for Coordination of Educational and Technological Research and Innovation
SNJ	National Youth Service
UI	User interface
UX	User experience
VET	vocational education and training

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Annex 1.

Table A 1. Makerspaces for young people

Lycée des Arts et Métiers	Creative Lab	https://www.ltam.lu/index.php?menu=539&page=1350&portal=45
Lycée Technique Ettelbruck	Maach3	http://maach3.makerspace.lu/
Lycée Technique d'Esch-sur-Alzette	cre8	https://www.lte.lu/initiatives/activites/cre8/
Lycée de Garçons Esch	UKLAB	http://lge.makerspace.lu/
Lycée Schengen de Perl	TryTestMake	
Lënster Lycée	Cre8tive	http://lensterlycee.lu/cre8ive/
Lycée Classique d'Echternach	Makerspace	
St. Anne Ettelbruck	Makerspace	
LTP Emile Metz	EM@B	http://www.ltpem.lu/?page_id=686
Lycée technique de Bonnevoie LTB	Makerspace	https://www.facebook.com/CreatorZoneLTB/
Maacher Lycée	Makerspace	
LN Wiltz – Makerspace		http://www.lnw.lu/index.php/homepage/makerspace
Forum Geesseknäppchen	Base 1	http://www.base1.lu/

Makerspaces for children

(a) Primary school/halfway houses (*maisons relais*) from Betzdorf (Site Rood/Syre);

(b) Primary school/halfway houses (*maisons relais*) from Dudelange (Sites Brill/Al Schwämm);

(c) Primary school/halfway houses (*maisons relais*) from Rosport;

(d) Base 1 Forum Geesseknäppchen Luxembourg city.